Midway Draft

MWLSF 6.2

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****** **First installment ends here.** *****

FIGURES

TABLES

4-3 Listing of Performance Monitoring Wells by Aquifer

1. INTRODUCTION

1.1 CLEANUP ACTION PLAN

1.1.1 PURPOSE

This document presents the draft Cleanup Action Plan (CAP) for the Midway Landfill located in Kent, Washington. This document is required by the site cleanup process established by the Washington Department of Ecology (Ecology) under Chapter 173-340 WAC, "Model Toxics Control Act--Cleanup Regulation", and meets requirements specified in WAC 173-340-360(10), "Draft Cleanup Action Plan."

It is Ecology's opinion that this documentation will satisfy the site remediation process specified in the Superfund Memorandum of Agreement between Washington State Department of Ecology and the U.S. Environmental Protection Agency (EPA) for Ecology lead sites which are on the National Priorities List.

The purpose of the draft CAP is to:

- o Summarize the results of the remedial investigation studies;
- o Summarize the cleanup and closure actions evaluated in the feasibility and endangerment assessment studies;
- o Summarize the selected cleanup and closure actions;
- o Summarize monitoring and management plans; and,
- o Provide a document through which public comment may be solicited regarding the selected cleanup and closure actions.

1.1.2 SCOPE

The draft CAP present the site description and history, then summarizes the results of the remedial investigation. These results are described in detail in several remedial investigation and feasibility study reports. The results are summarized in Sections 1 and 2 to provide background information pertinent to this document.

The draft CAP also presents the alternative actions evaluated for the cleanup and closure of the landfill. These alternative actions are described in detail in several feasibility studies and technical memoranda. The alternative actions are summarized in Section 3 to provide information to evaluate the cleanup and closure actions completed for the Midway Landfill.

1.1.3 APPLICABILITY

This cleanup action plan is applicable only to Midway Landfill site. The cleanup and closure actions have been developed as an overall remediation process conducted with Ecology participation.

1.1.4 THE DRAFT CAP AND THE CLEANUP PROCESS

The draft CAP is one in a series of documents used by Ecology to monitor progress of site investigation and cleanup.

The remedial investigation and feasibility study (RI/FS) documents present the results of investigations into the nature and extent of contamination of the landfill, assesses the risk posed by that contamination, and evaluate the feasibility of alternative methods of cleaning up the landfill. The investigations, assessments, and evaluations were performed according the Ecology approved work plans which were incorporated into a consent order written under the authority of Chapter 70.105D RCW the Hazardous Waste Cleanup-Model Toxics Control Act. The consent order requires that all activities conducted pursuant to its terms be consistent with the National Contingency Plan. The consent order was entered in Superior Court after a public review and comment period in May 1990.

The City of Seattle (Seattle) has completed the landfill investigations, assessments, and evaluations and submitted them in several remedial investigation and feasibility study documents which have been reviewed and approved by Ecology.

The draft CAP set forth requirements for cleanup and closure of the landfill for the affected environmental media (soil, ground water, surface water, and air).

Normally no final remedial action would begin until the Seattle had completed the RI/FS and Ecology had completed the CAP regarding the chosen cleanup alternative. Normally the CAP would indicate a discussion of Ecology's reasons for the final action, a response to any significant comment, any new data and any significant changes in the proposed remedial action plan.

However, in this case, Ecology has determined that capping the landfill, completing a gas extraction system, and completing the surface water management system prior to completing the CAP will provide immediate protection to the public health, welfare and the environment. By agreement set forth in the completed order, the capping, gas extraction and surface water system constructed by Seattle may be subject to modification or revision if the completed RI/FS contains significant new information.

The results of the RI/FS do not present information which changes the technical evaluation of the landfill condition and the remedial actions completed at the landfill.

1.2 SITE BACKGROUND INFORMATION

The City of Seattle Engineering Department, Solid Waste Utility, leased the 60-acre Midway Landfill site from Midway Sand & Gravel, Inc., and operated it as a landfill for eighteen years from 1966 to 1983. The site is currently owned by the City of Seattle.

The Midway Landfill is in South King County in the City of Kent, directly east of the City of Des Moines. Puget Sound is slightly more than a mile to the west. Residential areas surround the site, with the exception of a commercial strip along Highway 99 to the west. elementary schools and a community college are within one mile of the site. Interstate 5 (I-5) borders the site on the east. Approximately one mile east of I-5 is the Green River, which meanders north, becomes the Duwamish River, and enters Puget Sound. Figure 1-1 shows the location of the landfill and the landmarks in its vicinity.

From 1945 to 1966, the site was operated as a gravel pit. The pit originally was adjacent to a peat bog lake, Lake Meade, located northeast of the center of a present landfill (See Figure 1-2). As the pit was mined, water was drawn from the lake to wash silt and clay from the gravel and sand, then the water was returned to the lake. Silt and clay built up on the lake bottom. Near the end of the operation of the gravel mine the barrier between the lake and the gravel pit was broken, allowing the silty lake water to flow into the gravel pit. As a result, a clay/silt layer underlines much, but not all, of the landfill.

In January 1966, the City of Seattle leased the site and began using it a landfill for nonputrescible waste. Putrescible waste includes rapidly decomposing food scraps such as household and restaurant garbage. Nonputrescible wasted includes organic material that decomposes more slowly, such as the demolition debris and wood wastes that were deposited in the Midway Landfill. The landfill received demolition debris from commercial haulers and wood wastes and yard trimmings from the City's transfer stations.

Records beginning in 1980 indicate that some industrial wastes were deposited with the approval of the Seattle-King County Health Department. Information included in EPA's Emergency and Remedial Response Information System files indicates that the landfill may have received industrial liquid and sludge wastes before 1980. Much of this information is drawn from local newspaper articles and is otherwise unsubstantiated.

The landfill was closed in October 1983. Clean soil materials from excavation projects have been accepted at the site to assist in final grading and cover. During the course of operations at the landfill, an estimated 3 million cubic yards of solid waste were deposited. This waste covers approximately 40 acres and is up to about 130 feet deep in places. The entire site now covered with a variable layer of soil when operations ceased; it now appears as an open grassy area with scattered shrubs and a few areas of exposed soil.

The City closed the landfill in the fall of 1983 and began extensive testing of gas and water in the landfill and its vicinity. Samples of leachate and groundwater from monitoring wells in and around the landfill and gas samples from gas probes indicated the presence of organic and inorganic contaminants with a high potential for off-site migration. The Washington State

Department of Ecology also began investigating the site. In May 1986, the EPA placed the site on its National Priority List for cleanup. In August 1986, a remedial investigation was initiated by the City of Seattle, under the guidance of the Department of Ecology.

Measurements of water levels in leachate monitoring wells indicate that stormwater discharge from drainage pipes produce rapid and significant increases in water levels within the solid waste. It is assumed that stormwater entering the landfill becomes a contaminated leachate after contact with the waste. Since there is no surface runoff from the landfill, leachate must eventually enter the groundwater system if it does not remain in the landfill.

***** Please provide figures 1-1 and 1-2 *****

Figure 1-1. Location Map.

Figure 1-2. Topography of Gravel Pit in 1966.

1.3 NATURE AND EXTENT OF ENVIRONMENTAL PROBLEMS

1.3.1 SOLID WASTE

From 1966 to 1983, approximately 3 million cubic yards of solid waste were deposited at the 60-acre Midway Landfill. Borehole data indicate that the waste is up to 130 feet deep in some places; however, the exact volume of the buried solid wastes is not know.

The wastes accepted at the landfill were limited to demolition debris, industrial wastes approved by the Seattle-King County Health Department, and wood wastes and yard trimmings from the City's transfer stations. From 1980 to 1983, records indicate that paint sludges, dyes, preservatives for decorative plants, alkaline wastes, oily sludges, waste coolant, truck steam cleaning wastes, and some oily wastes were deposited at the site with the approval of the Seattle-King County Health Department. However, information from the EPA's Emergency and Remedial Response Information System indicates that the Midway Landfill also may have received industrial and hazardous liquid and sludge waste before 1980. Much of this information is drawn from local newspaper articles and is otherwise unsubstantiated.

Contaminated sediments have been disposed of or detected at the Midway Landfill. In 1983, lead-contaminated sediments were found in the South Pond. These sediments were excavated and disposed of at an approved hazardous waste disposal site. The South Pond was drained and filled in with clean soil. The quantities and location of any hazardous wastes that may have been deposited at the landfill are unknown. However, it is known that solid waste undergoes complex physical and chemical changes over time. Given the age of the landfill, the degree of compaction, and the mixture of wastes and soil, it is possible to characterize the waste indirectly through monitoring of the landfill gas, air emissions, leachate, groundwater, and surface water on or adjacent to the site.

1.3.2 LEACHATE

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Studies conducted during the remedial investigation established that large quantities of leachate are generated by infiltration from precipitation and direct discharge of storm water into the solid waste. Three wells currently monitor the leachate. Leachate samples were analyzed for conventional water quality parameters and compounds on the USEPA Hazardous Substance List (HSL).

***** Jeff: Are there more than three leachate monitoring wells? *****

Leachate samples were found to contain a variety of HSL compounds at trace levels; however, the leachate was not found to constitute a hazardous or dangerous waste according to the EP-Toxicity test or according to its corrosivity (Ph).

In addition to runoff from the surrounding natural drainage basin, the landfill receives stormwater directly piped into the refuse from the 89-acre Eastside basin. Stormwater is discharged into the North Pond from a third drainage basin of 87 acres that include the I-5 corridor and some of the adjacent property. Since the North Pond has no outlet, water must leave it by evaporation or infiltration. The North Pond is considered a major source of recharge to the landfill aquifer.

(Jeff: is the North Pond still a recharge source to the landfill?)

1.3.3 LANDFILL GAS

Landfill gas generated by the decomposition of solid waste within the landfill generally contain 40 to 60 percent methane. In the soil, methane presents little risk of explosion because there is very little oxygen. However, landfill gas is potentially explosive, if it collects in an enclosed space and reaches concentration of 4.8 to 15 percent by volume in the presence of oxygen.

In 1985, combustible gas was detected in structures up to 3,000 feet from the landfill. The City installed a series of gas migration control wells around the perimeter of the landfill and several offsite gas extraction wells in surrounding neighborhoods. These off-site and on-site gas extraction wells were installed as "expedited response actions". Ongoing testing and monitoring indicate that the control and extraction wells have been successful in reducing offsite gases, and most of the offsite gas control wells have been shut down.

The permanent onsite gas migration control wells are expected to continue in operation indefinitely as part of the final closure of the landfill. They provide a means of monitoring the rate of flow and the methane content of the gas. The average combined methane concentration throughout the migration control system is currently approximately 30 percent by volume. Many wells screened in the waste produce methane at levels over 40 percent.

(Jeff: is there still 40+% methane level production in the waste wells?)

Gas samples were analyzed from individual onsite gas extraction wells. Landfill gas was found to contain a wide variety of substances, including numerous USEPA Hazardous Substances List Volatile Organic Compounds (HSL VOCs). The compounds found most frequently and in the highest concentrations onsite included ethylbenzene, vinyl chloride, total xylenes, toluene, and benzene. The maximum concentration of these compounds were in the low part-per-million (ppm) range. Other HSL VOCs were found less frequently and in lower concentrations, generally in the parts-per-billion (ppb) range. The toxic inorganic gases hydrogen sulfide and carbon monoxide were also reported present onsite in the low ppm range. Hydrogen cyanide was not detected in onsite gas.

1.3.4 AIR EMISSIONS

In the Puget Sound climate, decomposition of landfill wastes produce methane, hydrogen sulfide, and carbon dioxide as by products of waste digestion.

Landfill emissions to ambient air were measured by comparing air samples from upwind and downwind of the site. Samples were analyzed for volatile organic compounds. Maximum concentrations of the chemical compounds detected were compared to ambient air quality guidelines.

The results did not support the hypothesis that the landfill produces significant hazardous air emissions. A few compounds were found at increased concentrations at downwind sampling sites, however, no compound was found consistently at greater concentrations at downwind sites. Many compounds were found at higher concentrations upwind of the landfill, or at off-site locations that were not downwind of the landfill. This indicates the presence of off-site sources of emissions unrelated to Midway Landfill. For example, the landfill is located between two major highways, Interstate 5 and Highway 99. Based on the upwind/downwind air sampling results, these highways appear to be significant sources of organic "aromatic" chemicals (compounds with a benzene-like structure).

In addition to the ambient air sampling program, the two temporary on-site gas flares that burn landfill gases collected in the gas extraction wells also were sampled. Each flare was sampled directly at the gas inlet and approximately 18 inches above the top of the flare stack. The samples were analyzed for volatile organic compounds. Results generally indicated that compounds present in the inlet gas were being destroyed to a varying extent by the flares.

(Jeff: do you have updated information about the destruction efficiency of the flares?)

1.3.5 GROUNDWATER

Groundwater samples were taken from approximately 40 locations in the vicinity of the Midway Landfill. Samples were obtained from 29 monitoring wells, 8 boreholes and 2 private wells. Sampling occurred on a complex schedule from October 1986 to September 1987, with additional sampling between October 1987 and March 1988. Samples were analyzed for conventional water quality parameters as well as HSL constituents.

Figure 1-3 shows the location of groundwater monitoring wells as of 1988.
(Jeff: provide: Figure 1-3. Groundwater monitoring well as of 1988.

HSL metals, semivolatile organics, and PCBs found at low levels in leachate were not found in downgradient groundwater. Metals were not detected in groundwater at concentrations exceeding background values for groundwater in similar geologic formations in this region. Pesticides and PCBs were not detected in groundwater. No acidic semi-volatile organic compounds were detected in groundwater, with the exception of some methylated phenols and benzoic acid in the ppb range in well MW-7. A localized source within or adjacent to the landfill is suspected as the source of contamination found in this well. Phthalates were detected in trace amounts in 12 groundwater wells.

A number of HSL VOCs were found in groundwater, for the most part in small (low ppb) amounts. Five wells exceed drinking water standards. Well MW-7 was found to contain compounds either not found elsewhere or at higher concentration than any other well. The volatile organics detected fall into three major groups: ketones, benzenes, and chlorinated solvents. All three classes of compounds were detected at MW-7. Many of these organics either were not detected in leachate or were detected at much lower concentrations in leachate. The specific compounds detected are all involved in the use of paints, varnishes, resins and plastics, either as solvents, swelling agents, thinners, or removers. Their presence at MW-7 probably represents a localized source within or adjacent to the landfill where compounds were disposed.

Chlorinated solvents were detected in groundwater wells at four locations. The specific compounds detected and their pattern of distribution strongly suggests that they did not originate in the landfill.

(Jeff: Please identify these four locations with chlorinated solvents. Provide information on the possible sources of the solvents if not the landfill.)

Several potential off-site sources of groundwater contamination were identified on the evidence of elevated sulfate, Ph, and calcium concentrations in groundwater located to the north of the landfill. Other off-site sources in the vicinity of, or north of, MW-10 and MW-17 are indicated by the distribution pattern of the VOCs detected.

1.3.6 SURFACE WATER

Surface water studies conducted indicate no evidence that the Midway Landfill is having a detrimental impact on the quality of surface water or soils in its vicinity. No surface water from the landfill discharges into any surrounding surface water bodies. Seeps emerging from the ground in the vicinity of the landfill do not show evidence of contamination attributable to the landfill. Analysis of surface water samples taken from 29 locations around the landfill showed that the water quality was within the range of typical urban runoff. It should be noted, that typical urban runoff often contains contaminants from highway vehicle emissions, petroleum products, solvents, and degreasers, and that this runoff may contribute contamination to the landfill.

2.0 INVESTIGATION RESULTS

2.1 LAND USE

A general description of land use in the Midway area, summarized in Figure 2-1, was provided in the Draft Environmental Impact Statement (Parametrix, 1985). **(Jeff: please provide complete citation for this reference in the reference section)** Businesses and some light industry and manufacturing cluster in a strip on both sides of Highway 99. The rest of the area is predominantly single-family residential, with one mobile home park to the north of the landfill, another to the southwest, and a few multi-unit residential developments to the west and south. Residences on South 252nd Street to the south of the site are within 100 feet of the site border. Residences across I-5 to the immediate east of the site are within 400 feet of the landfill perimeter.

Two elementary schools, Sunnycrest Elementary School and Parkside Elementary School, and a city park, Linda Heights Park, are within a half-mile of the site. Highline Community College is northwest of the landfill. In 1988 Highline had 3,623 full-time and 4,652 part-time students and 629 full-time employees. Over 80% of the students live outside of the area.

An undeveloped wooded area of 8 acres borders the landfill on the north; other vacant lots dot the landscape. A 6-acre wetland to the east of the Parkside Elementary School and west of the landfill currently functions as a detention basin for surface water runoff, primarily from the west side of Highway 99.

2.2 WATER WELL INVENTORY

The water well inventory originally conducted as part of the Final Environmental Impact Statement for the Midway Landfill Closure Plan (Parametrix 1986) **(Jeff: please provide complete citation for this reference in reference section)** was updated for the RI (Appendix C of the Groundwater Technical Report). The purpose of the inventory was to identify groundwater users who might be potential receptors of leachate-contaminated groundwater. The original inventory found 23 water wells a one-mile radius of the site. During the RI three additional private wells and five additional public wells were identified.

Figure 2-2 shows the locations of the 31 wells now listed. Five wells, all in the Lake Fenwick area to the southeast of the landfill, are known to be in use for drinking water. Three private wells are used for domestic purposes other than drinking water. One other may be operating but present use could not be verified. Twenty-two are known to be unused, and of those, 13 are not operable.

Figure 2-2. Locations of Private and Public Wells Within a One Mile Radius of the Midway Landfill.

Please show which wells are in use. Please provide figure.

2.3 HYDROGEOLOGIC INVESTIGATIONS

Most of the hydrogeologic information was obtained from the groundwater and leachate monitoring wells, probes, and boreholes drilled for the remedial investigation. Previous studies conducted in the early 1980s for the City of Seattle (reported in the Draft and Final Environmental Impact Statements for the Midway Landfill Closure Plan, Parametrix, 1985 and 1986) yielded some hydrogeologic data about shallow substance conditions, but were not sufficient to identify the aquifers underlying the landfill or to evaluate groundwater quality or the impact of leachate on the groundwater system.

The hydrogeologic studies conducted for the remedial investigation are described in detail in individual technical memoranda that are included as appendices to the Groundwater Technical Report (Seattle, 1988d) and the Groundwater Remediation Status Report (Seattle, 1994).

(Jeff: please provide complete citations for these references in reference section)

2.3.1 METHODOLOGY

2.3.1.1 Hydrogeology

Existing information on the geology and hydrology of the landfill and the history of mining operations and landfill development was reviewed. Included in the review were existing geologic and topographic maps of the area as well as aerial photographs from 1965, 1976, and 1978. People associated with the gravel mining operations were interviewed and historical gravel pit maps were obtained from Washington State Department of Transportation.

During the remedial investigation 47 monitoring wells (designated "MW") ranging from 20 to 377 feet deep and 10 gas probes ranging from 72 to 220 feet deep were installed in 23 drilled borings. The borings were designated MW-7 to MW-29; individual well completions within borings were designated as A, B, or C, with A being the shallowest completion and C the deepest. Three additional shallow groundwater monitoring wells were installed in the Parkside Wetland. These wells, designated DP-1 to DP-3, were installed by driving stainless steel well points to a depth of approximately 6 feet. Two 6-inch diameter leachate wells were installed, one in the northern and one in the southern part of the landfill. These wells, designated LW-1 and LW-2, respectively, were designed as extraction wells in case future remedial actions involved leachate removal. Well locations are shown on Figure 1-3. Table 2-1 list the wells by hydrostratigraphic unit.

Table 2-1. List of monitoring wells by hydrostratigraphic unit.

Aquifer hydraulic characteristics were evaluated by conducting slug injection and withdrawal tests. Step drawdown pumping tests were conducted in both leachate wells to evaluate the landfill waste hydraulic characteristics and also the wells' capacity and performance. A comprehensive laboratory testing program was undertaken to evaluate the physical properties of the soil samples that were recovered during drilling.

The City of Seattle or its consultants have been monitoring groundwater elevations in the wells since 1983. Beginning in late 1986 with the installation of MW-7, the City began adding each new remedial investigation well to the monitoring program as it was completed.

A specific supplementary investigation was developed for the Parkside Wetland because of its proximity to the landfill and the pronounced public sensitivity to potential contamination in it. An inventory of private and public wells within one mile of the landfill was conducted to identify users of groundwater that might potentially receive contamination from landfill leachate.

2.3.1.2 Geochemistry

Groundwater and leachate monitoring wells were sampled and the samples analyzed according to procedures outlined in the Final Sampling and Analysis Plan prepared for the Washington Department of Ecology by Black & Veatch (July, 1986) and the Quality Assurance Project Plan prepared for the City of Seattle by Parametrix (December 1986). **(Jeff: please provide complete citations for these references in reference section)**

Monitoring wells were sampled four times each during the course of the investigation. In addition, two selected domestic wells were also sampled four times each. Each existing well was sampled as soon as possible at the start of the sampling program. Those wells not completed were sampled soon after their completion. All wells were sampled again after completion of the entire drilling program, then again during two more sampling rounds spaced at 12-week intervals.

The sampling schedule was revised in response to delays, changes, and additions to the drilling program. As a result, some wells were sampled two or three times before others were sampled for the first time. Sampling Round 4 is the only round in which all wells were sampled at the same time. Wells constructed after the completion of a sampling round were sampled half-way (6 weeks) between rounds. Table 2-2 shows when each well was sampled during this investigation.

Table 2-2. Monitoring wells sampled during remedial investigations.

Analytical Technologies, Inc. (ATI), in San Diego, California was contracted as the main laboratory to perform analyses on Midway RI groundwater samples. The groundwater samples were analyzed for general water quality parameters and the CERCLA Hazardous Substances List, including cyanide, dissolved metals, volatile and semivolatile organics (including acid extractable and base neutral organics), pesticides, and PCBs. Laucks' Testing Laboratories in Seattle analyzed the samples for coliform bacteria.

Quality assurance samples were analyzed by four different labs. ATI performed analysis on duplicate samples, blanks, and rinse samples. Laucks Testing Laboratories, Inc., performed analyses on replicates and samples taken for coliform bacteria determination. During the implementation of the groundwater and leachate monitoring program, responsibility for the bacterial determination was transferred from Laucks' to the Department of Health Laboratory in Seattle. At about the same time, responsibility for replicate sample analysis was transferred from Laucks' to Analytical Resources, Inc. of Seattle.

2.3.2 GROUNDWATER CONDITIONS IN THE MIDWAY VICINITY

2.3.2.1 Aquifers

The hydrogeology of the Midway study area is extremely complex. The sediments underlying the area are diverse and completely interbedded, and include sediments deposited during two glaciations and one interglacial period. Eight distinct hydrostratigraphic units were identified in the study area:

- Perched Aquifers
- Landfill Aquifer
- Upper Gravel Aquitard
- Upper Gravel Aquifer
- Upper Silt Aquitard
- Sand Aquifer
- Lower Silt Aquitard
- Northern and Southern Gravel Aquifers

Figure 2-3 shows a schematic interpretation of the relationship between geologic and hydrostratigraphic units; Figure 2-4 is an actual hydrogeologic cross section showing these relationships beneath the landfill.

Figure 2-3. Generalized hydrogeologic cross-section. Jeff please provide.

Figure 2-4. Hydrogeologic cross-section beneath landfill. Jeff please provide.

The major aquifers beneath the landfill are the Upper Gravel Aquifer, the Sand Aquifer, and the Northern and Southern Gravel Aquifers. Each aquifer has unique hydrogeological properties, including flow direction and rates. Accordingly, contaminants entering or moving between the aquifers migrate in different directions and at different rates. The aquifers and aquitard are described below, in order from ground surface downward.

Perched Aquifers. The perched aquifers and near-surface seasonal groundwater bodies around the landfill are perched on unweathered Vashon Till are in outwash gravels. These bodies typically occur near the base of the fill, in Recent Alluvium, Vashon Recessional Outwash, on in other permeable surficial soils underlain by less permeable soils. Two perched aquifers are of significance to this investigation: one occurs in the Parkside Wetland west of the landfill and another occurs in outwash gravels immediately north of the landfill east of well MW-21.

Landfill Aquifer. Leachate forms a nearly continuous body of water at the base of the landfill, and also occurs as scattered perched water bodies within the landfill. These various water bodies collectively make up the Landfill Aquifer.

In February 1987, leachate elevations measured in the three leachate monitoring wells and all the on-site gas extraction wells averaged 30 to 40 feet higher in the northern half of the landfill than in the southern half. The difference in elevation is the result of several factors:

- The base of the northern portion of the gravel pit is higher in elevation than the southern portion.
- Fine-grained pond sediments at the base of the northern portion of the landfill tend to restrict vertical flow.
- A dike used to separate the northern and southern areas of the former gravel pit may still be partially or wholly intact.
- The northern part of the landfill receives significant direct recharge from surface water runoff and from perched water in the outwash gravel north of the landfill.

As a result, leachate flow is likely to be from the north and west, where the landfill base elevation is high, toward a low area in the southeastern part of the original pit.

Leachate thickness also appears to increase from east to west in accordance with the general deepening of the original gravel pit excavation. A maximum saturated thickness of 40 feet was observed in the northern half of the landfill.

Upper Gravel Aquitard. The Upper Gravel Aquitard consists of low permeability, poorly sorted silt-bound outwash gravel that tend to retard groundwater movement. This unit typically consists of 50- to 100-foot thick beds of silty gravel interbedded with more permeable sand and sandy gravel zones. The Upper Gravel Aquitard extends from near land surface to the first major bodies of permeable gravel, which typically occur near the base of the outwash gravel.

Upper Gravel Aquitard. The first major aquifer beneath the landfill occurs near the base of the outwash gravel, within a buried channel and its tributary channels. The channel deposits are gravel. Groundwater occurs in the Upper Gravel Aquifer under water table (unconfined) to slightly confined conditions. Figure 2-5 shows the approximate extent of the Upper Gravel Aquifer.

Figure 2-5. Upper Gravel Aquifer Distribution. Jeff please provide.

Upper Silt Aquitard. A 5- to 40-foot-thick sequence of fine-grained silt and silty fine sand designed as the Upper Silt Aquitard underlies the Upper Gravel Aquifer throughout much of the study area. However, there is a gap or window in the aquitard extending north-south of the landfill. There is another gap in the aquitard west of the area south of the landfill. There is another gap in the aquitard west of the landfill. The north-south window in the aquitard that erosion removed the Upper Silt Aquitard from this area during the deposition of the outwash gravel. Figure 2-6 shows the approximate extent of the Upper Silt Aquitard.

Figure 2-6. Upper Silt Aquitard Distribution. Jeff please provide.

Sand Aquifer. The Sand Aquifer consists of saturated deltaic sediments beneath the Upper Silt Aquitard. The top of the Sand Aquifer occurs between elevation 180 and 240 feet. The Sand Aquifer is typically confined; however, unconfined conditions prevail in the southeastern portion of the study area. The distribution of saturated sand deposits within the deltaic sediments varies considerably throughout the study area. In some places there is considerable interbedding between saturated sand and fine-grained silts. Sand bed thickness ranges from 30 to 80 feet.

Lower Silt Aquitard. Fine-grained silt and silty sand occur in many parts of the study area between Elevations 100 and 180 feet, at the base of the deltaic sediments. These fine-grained sediments, collectively called the Lower Silt Aquitard, underline the Sand Aquitard in many areas and interfinger with it in others. The Lower Silt Aquitard ranges in thickness from 0 to a maximum of approximately 50 feet. Maximum thickness are located beneath the south central portion of the landfill and directly east of the landfill. The aquitard appears to be absent in a band extending across the north part of the landfill and in the eastern part of the study area. Figure 2-7 shows the approximate extent of the Lower Silt Aquitard.

Figure 2-7. Lower Silt Aquitard Distribution. Jeff please provide.

Northern and Southern Gravel Aquifers. Groundwater occurs under confined conditions in gravel beds within the nonglacial sediments. These gravel beds typically range from 5 to 30 feet thick and are separated by intervening lower permeability silty sandy gravel and silt beds. Apparently two separate aquifers, the Northern Gravel Aquifer and the Southern Gravel Aquifer, exist beneath the site; potentiometric heads in this stratum average 90 feet higher in the northern part of the study area than in the southern part. The apparent boundary separating the two aquifers trends east-west across the middle of the landfill between wells MW-18 and MW-19.

2.3.2.2 Groundwater Recharge and Flow

Recharge of aquifers beneath the Midway Landfill occurs by infiltration of precipitation and surface water runoff and by lateral regional groundwater flow. Recharge to the Landfill Aquifer occurs through discharge of surface water into the landfill, infiltration through the cap and North Pond, and lateral flow from the area of perched groundwater north of the landfill.

No recharge occurs from the Upper Gravel Aquifer, since most of it is below the landfill. Infiltration and stormwater discharge from Linda Heights and the I-5 corridor are the major sources of recharge.

Leachate flow in the Landfill Aquifer is generally toward the deepest area of gravel pit operations, located in the southeastern portion of the landfill. The generalized Landfill Aquifer potentiometric surface is illustrated in Figure 2-8.

Figure 2-8. Landfill Aquifer Potentiometric Surface. Jeff please provide current data. Show flow lines.

The Upper Gravel Aquifer also receives recharge from precipitation, as well as from the overlying Perched and Landfill Aquifers, and through lateral flow from area north and south of the study area. Seasonal water level fluctuations in most of the wells range from 5 to 25 feet. Water levels do not appear to respond to any single precipitation event, but to seasonal increases or decreases in precipitation. Water levels generally increase to their highest level approximately 2 to 3 months after the seasonal peak precipitation.

The groundwater flow pattern in the Upper Gravel Aquifer is shown in Figure 2-9. This flow pattern is indicative of lateral flow from areas north and south of the landfill. From north of the landfill, groundwater in the Upper Gravel Aquifer flows to the east near MW-29 and to the west in the vicinity of MW-25 at the Parkside Wetland. Groundwater in the Upper Gravel Aquifer flows from the north and south toward an apparent hydraulic sink located near the southern border of the landfill.

Figure 2-9. Upper Gravel Aquifer Potentiometric Surface. Jeff please provide current data. Show flow lines.

The Sand Aquifer is recharged by groundwater flowing down through gaps in the Upper Silt Aquitard. Lateral groundwater flow in the Sand Aquifer is generally from north of the landfill southeastward toward a depression in the potentiometric surface located near the southeastern corner of the landfill, as shown in Figure 2-10.

Figure 2-10. Sand Aquifer Potentiometric Surface. Jeff please provide current data. Show flow lines.

There is also a strong component of vertical flow downward in the Sand Aquifer. Typical vertical hydraulic gradients range from 0.5 to 0.6, in contrast to horizontal hydraulic gradients ranging from 0.02 to 0.1.

The Northern and Southern Gravel Aquifers underlie the Sand Aquifer. Groundwater in the Northern Gravel Aquifer flows from north to south and appears to be truncated at an east-west line extending across the study area. Groundwater in the Southern Gravel Aquifer, which occurs south of this east-west line, flows to the east and west away from a groundwater divide or mound located near the southeastern corner of the landfill (see Figure 2-11).

Figure 2-11. Northern and Southern Gravel Aquifers. Jeff please provide current data.

Show flow lines.

Comparison of the Sand Aquifer potentiometric surface with that of the Southern Gravel Aquifer shows that the hydraulic sink in the Sand Aquifer is located directly over the Southern Gravel Aquifer divide, indicating that the groundwater divide may be caused by recharge from the Sand Aquifer.

2.3.2.3 Groundwater Discharge

An interpretation of regional groundwater flow conditions beneath and in the vicinity of the study area is shown in Figure 2-12. Groundwater pathways outside of the study area remain poorly understood. As depicted, groundwater within the Des Moines Drift Plain, where the landfill is located, generally migrates downward and to the west toward Puget Sound, or to the east toward the Green River Valley. It most likely discharges to Puget Sound or the Green River Valley, with some portion migrating to deeper aquifers. Some of this groundwater may be withdrawn by water supply.

Figure 2-12. Regional Groundwater Flow Patterns near the Midway Landfill. Jeff please provide. Show current data.

The principal potential groundwater discharge areas for source near the Midway Landfill are perennial streams or springs flowing to Puget Sound or the Green River Valley, including Smith Creek and other smaller, unnamed drainages, and possibly the domestic water supply wells in the Lake Fenwick area.

The ultimate discharge point is not know for either the Northern or Southern Gravel Aquifers. However, considering these aquifers are 50 to 100 feet above sea level, it is anticipated they discharge to Puget Sound or to sediments in the Green River Valley.

2.3.3 CHEMICAL ANALYSES OF LEACHATE AND GROUNDWATER

2.3.3.1 Leachate Composition

Landfill leachate is formed as water percolates through the solid and semi-solid mass of the landfill. As the water percolates it leaches organic and inorganic compounds from the landfill mass.

Compounds that are in the leachate may also absorb onto the landfill materials or react with other components in the leachate and precipitate out of solution. The chemical composition of the leachate is distinctive for each landfill and can act as a tracer of the landfill's impact on the groundwater. Leachate and groundwater are readily distinguishable from one another on the basis of relative concentration of constituents.

The most common chemicals found in landfill leachate are the general mineral cations (calcium, magnesium, sodium, potassium) and anions (chloride, sulfate, fluoride, nitrate/nitrite, and carbonate/bicarbonate). These chemicals are common because they are present in most waste and because they are extremely soluble in water. They come from many sources and are present in all groundwater, including that used for drinking water; but elevated concentration of these components are often good indicators of the presence of leachate.

The groundwater and leachate were found to contain the same suite of general mineral compounds; but the leachate contained much higher concentrations than the groundwater in the Midway vicinity. For most of these parameters, Midway Landfill leachate concentrations were at least 10 to 50 times higher than background concentrations.

Table 2-3 presents a summary of chemicals contaminants detected in leachate along with the federal drinking water standards and the MTCA groundwater standards. The extent of leachate migration is shown in Figure 2-13.

Table 2-3. Concentrations of Hazard Substance List Compounds in Midway Landfill Leachate.

Jeff please provide updated data for this table. Compare concentrations to drinking water standards (primary or secondary as appropriate) and MTCA Method B.

Figure 2-13. Extent of Leachate and Leachate Affected Groundwater. Jeff please provide current data for this figure.

The leachate does not meet secondary drinking water standards, such as those for chloride, color, iron, odor, and total dissolved solids; however, these standards are based on aesthetic rather than health criteria.

The leachate does not meet MTCA Method B Cleanup standards for arsenic, chromium, copper, naphthalene, bis(2-ethylhexylphthalate) and benzene. ******* Jeff: is this still a true statement? Are there chemicals to add or delete from this list? *******

2. 4 RESULTS OF GROUNDWATER CHEMISTRY MONITORING

The groundwater chemistry monitoring that has been conducted at Midway Landfill was evaluated for the remedial investigation, the endangered assessment, and the feasibility study. The results of the feasibility study indicate that contaminant concentrations in groundwater is apparently consistent at various distances from the landfill. The feasibility study also concluded that "under current use conditions, areas with detectable groundwater contamination attributable to the landfill pose no risk to human health" (Parametrix 1990). The feasibility study concludes that source control is the preferred approach to groundwater contamination (Parametrix 1990).

Jeff: Please provide the Parametrix 1990 citations in the bibliography.

The chloride dilution monitoring conducted during the endangered assessment and used during the feasibility study in conjunction with flow system calculations suggested that even after leachate generation is stopped or minimized there will be a delay in observed decreases in groundwater contamination. Already, some improvements in downgradient monitoring wells have been observed in that some are dry, and specific declines have been observed in some trend plots as discussed below.

2.4.1 TREND ANALYSES

Groundwater chemistry has been both monitored and reported on a quarterly basis during the RI and FS phases. These quarterly monitoring (QM) rounds began in February 1990 with QM-1. Engineering controls were still being taken during rounds QM-1 through QM-7 (December 1991), with the Linda Harris Park cutoff being activated in January 1992. A description of groundwater chemistry trends, by aquifer, is listed in the following sections. In general, aquifer conditions have improved significantly in the Upper Gravel Aquifer show some limited improvements in the Sand Aquifer, and appear to remain at steady state in the Sand and Gravel Aquifer.

Jeff: please provide description of contaminant trends for the recent data.

2.4.1.1 Upper Gravel Aquifer (UGA)

Downgradient wells MW-7A and MW-19B (Figure __), chosen to monitor UGA water quality at points where leachate was believed to directly enter the UGA, have been dry since March and December of 1992, respectively. Prior to going dry, their water quality had been fairly steady, probably indicating that their assumed placement at a point of leachate discharge into the UGA was correct. Their current dry condition does not necessarily indicate that no leachate is reaching the UGA, but that the leachate volume is so reduced that the whole water surface in the UGA has decreased to below the well screens. The leachate reduction was probably related to the activation of the Linda Heights Park cutoff and the completion of the landfill cap. The decrease in water levels in these wells indicates a decreased driving force for leachate migration out of the landfill.

Figure ____. Jeff: please provide appropriate figure showing well locations or use a previously cited figure to show well locations.

2.4.1.2 Chloride

Chloride concentrations in landfill leachate are known to be significantly elevated above background levels. For this reason and because of its chemical properties, chloride can be considered a indicator of landfill leachate migration.

Chloride levels in the upgradient wells (MW-16 and MW-21A) have been generally stable since measurements began during the RI. Both of the downgradient wells (MW-7A an MW-

19B) have had consistently higher levels of chloride than the upgradient wells. These levels showed an increase to above RI levels at the beginning of quarterly monitoring, then a decrease to RI levels, before the wells went dry in 1992.

Jeff: do you want add any more to this section to include recent quarterly sampling results for wells that are not dry?

2.4.1.3 Chemical Oxygen Demand (COD)

Levels of chemical oxygen demand in the upgradient wells and downgradient well MW-19B have been stable since measurements began in the RI. COD levels in MW-7A decreased between the RI and 1992 when the well went dry.

Jeff: do you want add any more to this section to include recent quarterly sampling results for wells that are not dry?

2.4.1.4 Conductivity

Levels of conductivity in the upgradient wells and in downgradient well MW-19B have been stable since measurements began in the RI, although levels in MW-19B have fluctuated within a larger range of values than the upgradient wells. Conductivity levels in MW-7A decreased between the RI and 1992.

Jeff: do you want add any more to this section to include recent quarterly sampling results for wells that are not dry?

2.4.1.5 Organic Compounds

Chlorinated solvents have not been detected in the upgradient wells in the UGA and concentrations of chlorinated solvents in the downgradient wells decreased since the RI. No chlorinated solvents have been detected in the downgradient wells since QM-6, and by QM-9 (MW-7A) and QM-11 (MW-19B), the well were dry.

Jeff: do you want add any more to this section to include recent quarterly sampling results for wells that are not dry?

Table 4-1 presents organic compounds that are detected in the UGA.

Jeff: please provide table 4-1 that shows organic compounds detected in each well in the UGA. Please let me know if you agree whether or not a figure should be provided here to show contaminant distribution.

2.4.2 Sand Aquifer (SA)

Downgradient wells, MW-15A and MW-23A, chosen to intercept contaminated groundwater from the UGA as it flowed through the SA and downward to the SGA, have been dry since QM-13. Well MW-20A was monitored during the RI, but was only added to the quarterly rounds beginning with QM-10. The decrease in water levels in MW-15A and MW-23A is believed to be a direct consequence of the reduction of water levels in the UGA, which in turn is a consequence of the significant reduction in the volume of leachate leaving the landfill since engineering controls took effect.

Jeff: Please add a description of on-going quarterly sampling results to this section.

2.4.2.1 Chloride

Chloride levels in the upgradient wells (MW-8B, MW-17, MW-21B, and MW-30B) have been stable since the beginning of monitoring during the RI. Levels in the downgradient wells (MW-15A and MW-23A) have decreased since the RI. Beginning with QM-11, chloride levels in MW-23A showed a steady decline until the well went dry beginning in QM-14. Chloride levels in MW-15A have shown a relatively steady decline since the beginning of the RI.

Well MW-20A is considered neither upgradient nor downgradient due to its position directly adjacent to the landfill. This well has had a relatively steady decrease in chloride levels, similar to MW-23A, indicating that it may be influenced by landfill leachate.

Jeff: Please add a description of on-going quarterly sampling results to this section.

2.4.2.2 Chemical Oxygen Demand

COD levels in the SA wells have generally been stable. There has been an apparent decrease in COD levels in MW-20A.

Jeff: Please add a description of on-going quarterly sampling results to this section.

2.4.2.3 Total Organic Carbon

TOC levels in the SA are generally stable in the upgradient wells. TOC levels in downgradient wells MW-23A and MW-15A decreased, particularly between 1992 and when they went dry in 1993. Levels in MW-20A may be decreasing, but there are not enough data to show a clear trend.

Jeff: Please add a description of on-going quarterly sampling results to this section.

Please describe trend(s).

2.4.2.4 Conductivity

Conductivity levels in most of the upgradient wells have been relatively stable, except in MW-17B which has shown a slight increase. The downgradient wells showed a slight decrease in conductivity levels between 1992 and when they went dry in 1993. Conductivity levels in MW-20A appear to be decreasing, although there are not enough data to show a clear trend.

Jeff: Please add a description of on-going quarterly sampling results to this section. Please describe trend(s).

2.4.2.5 Organic Compounds

Concentrations of chlorinated solvents have increased markedly upgradient well MW-17B between the RI and the QM rounds and appear to be continuing to increase slowly. However, they have increased only slightly in upgradient MW-21B. Chlorinated solvents have been generally undetected in the rest of the upgradient wells. Downgradient wells MW-15A and MW-23A have had decreased levels of chlorinated solvents between the RI and when the wells went dry in 1993. Levels of chlorinated solvents in MW-20A have not shown any significant change.

Table 4-2 presents organic compounds that were detected in the SA during the RI and are no longer detected.

Jeff: please provide table 4-2 that shows organic compounds detected in each well in the SA. Please let me know if you agree whether or not a figure should be provided here to show contaminant distribution.

2.4.3 Southern Gravel Aquifer (SGA)

No wells in the SGA have gone dry, however, the water levels in MW-19C, MW-20B, MW-14B, and MW-29B have decreased, indicating that the impact of decreased discharge of leachate into the groundwater system has been felt all the way to the SGA.

The following compounds in the SGA have been relatively stable (or varied within a stable range): manganese, iron, sulfate, nitrogen species, COD, and conductivity.

Jeff: Please add a description of on-going quarterly sampling results to this section. Please describe trend(s).

2.4.3.1 Chloride

Chloride levels in upgradient well MW-24B have been stable since the beginning of monitoring. Levels in the downgradient wells have been generally stable with a slight decrease in chloride levels in MW-14B and a slight increase in levels in MW-20B. The decrease in MW-14B may be the first indication of improvement in the SGA.

Jeff: Please add a description of on-going quarterly sampling results to this section. Please describe trend(s).

2.4.3.2 Total Organic Carbon

TOC levels in the SGA have been relatively stable in all wells, except for a decrease in downgradient well MW-20B and a slight decrease in MW-14B since the RI. These decreases may be the first indication of improvement in the SGA.

Jeff: Please add a description of on-going quarterly sampling results to this section. Please describe trend(s).

2.4.3.3 Chlorinated Solvents

Chlorinated solvents have not been detected in upgradient well MW-24B or downgradient well MW-30C during any of the monitoring events. Chlorinated solvent levels in MW-14B have decreased since the RI. Low levels of one chlorinated solvent (1,2-dichloroethane) have consistently been detected in downgradient well MW-29B; levels have been stable. Levels of chlorinated solvents in MW-23B have also been relatively stable, varying within a constant range.

Jeff: please update this section with the on-going quarterly sampling results.

2.5 OFF-SITE SOURCES OF GROUNDWATER CONTAMINATION

It is possible that some of the contaminants found in groundwater in the Midway area may not have originated within the landfill. Other possible sources include the following:

2.5.1 Recharge to the Landfill

Water has entered the Midway Landfill from a variety of sources, including, in order of volume, direct infiltration of precipitation, diverted runoff from the I-5 corridor and adjacent drainage basins and groundwater discharge. The amount of recharge to the Landfill Aquifer from infiltration and drainage is estimated to be from 65 to 120 million gallons per year.

Numerous studies have shown that highway runoff is contaminated with metals, total dissolved solids (TDS), and polyaromatic hydrocarbons (PAHs) (Municipality of Metropolitan Seattle, 1982; Eganhouse, et al., 1981; Hoffman, et al., 1984). The diverted runoff from the 87-acre I-5 corridor basin is probably contributing contamination to the landfill. The groundwater from the perched aquifers to the north of the landfill is also believed to be contaminated from a chemical transport facility to the north, and with other contaminants from other off-site sources. Consequently, limiting recharge from the highway runoff and from the perched aquifers will decrease the load of contaminants going into the landfill.

Jeff: please provide complete citation of references cited above.

2.5.2 Geochemical Evidence

At Midway Landfill, chloride is a tracer for leachate. Most of the chloride in excess of background levels is attributable to landfill influence. The leachate plume was traced by identifying the distribution of chloride concentrations in excess of background levels, i.e. greater than 1.8 to 6.5 mg/L. The fact that the perched aquifers to the north and upgradient of the landfill contain elevated chloride concentrations (13 - 15 ppm) suggests that there may be another source of chloride to the north of the landfill.

Areal plots of sulfate, pH, calcium, and hardness distribution by aquifer also show anomalous values in areas that are upgradient of the landfill.

Jeff: please provide figure that shows the areas of anomalous values that indicate potential off site sources.

2.5.3 Landfill Vicinity Businesses

Pacific Highway South, along the western border of the landfill property, is a major industrial and commercial corridor. It is likely that some businesses in the landfill vicinity have used some hazardous substances. Prior to 1960, the area was substantially rural.

A search of past and current city business directories and phone books yielded 21 business locations within 3,500 feet of the landfill where hazardous chemical substances are likely to be used, or to have been used, judging by the nature of the business activities. These businesses include dry cleaners, automobile repair and painting shops, plastics extruders and fiberglass boat builders, and a chemical transport facility.

Any hazardous chemicals that contaminate the ground in the business district bordering the landfill could enter the groundwater system by means of infiltrating surface water and could easily pass beneath the landfill. As this contaminated groundwater passed under the landfill, it would mix with the leachate plume and complicate the chemical picture downgradient of the landfill.

2.5.4 Contamination in the Perched Aquifers

Several volatile organic compounds have been detected in sediment samples taken from excavated sludges removed from unlined impoundments near the landfill. These impoundments are located on property north and hydraulically upgradient of the Midway Landfill. Some of the same compounds were detected in contaminated groundwater hydraulically downgradient from this site.

The seasonal perched aquifers situated north of the landfill, had elevated concentrations of chloride and sulfate and contained toluene, ethyl benzene, and xylenes at low ppb levels. As these volatile compounds leach from the soil column, they could be transported into the landfill from the perched aquifers.

2.5.5 Chlorinated Ethane Sources

The sources of ethane contamination at Midway may be from the landfill or an off-site source. An off-site source may be possible for the following reasons:

- No ethanes were detected in the leachate.
- The ethanes decrease in concentration as they move along the flow path from MW-17 toward the landfill.
- Parent compound (TCA), which usually decays before it has time to move far downgradient, is present at MW-17 and not in downgradient wells.
- The chloride is elevated in MW-17B and MW-10A, whereas the volatiles are present in MW-17A and MW-17B. If they are both from the leachate, they should travel together.
- Localized surface contamination in the area would be leached by rainwater, which directly recharges both the Upper Gravel Aquifer (MW-17A) and the Sand Aquifer (MW-17B).
- Local area businesses near MW-17/10 are plastics extruders and auto repair shops. These businesses are likely to use or to have used TCA as a solvent and degreaser, respectively.

2.6 RECEPTORS

All three major aquifers beneath the landfill have a component of flow to the east or southeast, as shown in Figures 2-8, 2-9,2-10 and 2-11. The Green River Valley and Lake Fenwick, to the east and southeast of the landfill respectively, are potential receptors of groundwater from the landfill area, as are the five private wells in use in the Lake Fenwick area. A small quantity of groundwater is moving to the west or southwest toward either the North or South Fork of Smith Creek.

2.6.1. The Green River Valley and Lake Fenwick

Most, if not all, of the leachate that enters the Upper Gravel Aquifer from the Landfill Aquifer flows vertically downward into the Sand Aquifer. No impact from leachate has been found in the Upper Gravel Aquifer east of the landfill. On the southeast of the landfill the Upper Gravel Aquifer flows toward the landfill. It is unlikely that leachate-impacted groundwater in the Upper Gravel Aquifer flows towards the Green River Valley or Lake Fenwick.

Although leachate has affected the groundwater in the Sand Aquifer, as indicated by the elevated concentrations of chloride in MW-14 (at the landfill's eastern border), the water at MW-14 does not violate federal primary drinking water standards. Chloride dilution calculations show that the chloride concentration should be indistinguishable from background levels within 3,000 feet of the landfill border. Other substances in the leachate would be below detection limits much sooner because their initial concentrations in the landfill are much lower than chloride.

Similar considerations apply to groundwater in the Southern Gravel Aquifer, which also flow to the east and could reach the Green River Valley. It is calculated that the chloride attributable to leachate influence will be at background concentrations at 3,000 feet from the landfill to the east and that no detectable impact from the landfill will occur beyond this area.

It is unlikely that the Southern Gravel Aquifer also moves to the west toward Smith Creek. No evidence of leachate contamination was found in seeps tested in this area.

2.6.2 Smith Creek

Groundwater in a small portion of the Sand Aquifer near MW-25 and possibly MW-17 may eventually discharge into Smith Creek. The discharge point closest to MW-25 would be approximately 2,600 feet to the southwest. Given the estimated groundwater velocities in the Sand Aquifer, travel time would be on the order of 20 to 30 years. Since no sign of leachate impact was detected at MW-25, no impact is expected downgradient of the well.

Groundwater in the Uppper Gravel Aquifer adjacent to and north of the Parkside Wetland discharges to a branch of the North Fork of Smith Creek or to the wetland. Groundwater flows from the landfill into that portion of the Upper Gravel Aquifer.

2.6.3 Parkside Wetland

No major route of groundwater flow was found from the landfill to the Parkside Wetland. No evidence is seen of leachate-impacted groundwater reaching the Parkside Wetland.

2.7 RELATIONSHIP OF SURFACE WATER RESULTS TO GROUNDWATER

The Surface Water Technical Report (Seattle, 1988) included studies of surface water bodies in the landfill vicinity as well as analyses of storm water, seeps, and soils.

Jeff: please provide complete citation of (Seattle, 1988) in the reference section.

2.7.1 Surface Water

Surface water samples collected and analyzed during the remedial investigation were found to be representative of typical urban runoff. This suggests that the landfill does not directly affect local surface waters. The landfill is a drainage basin which receives, but does not discharge surface water.

2.7.2 Storm Water

Stormwater samples collected from the I-5 drainage corridor showed low levels of trichloroethene, tetrachloroethane, and total xylenes. Other studies of storm water have shown that metals and PAHs are also likely contaminants (Municipality of Metropolitan Seattle, 1982; Eganhouse, et al., 1981; Hoffman, et al., 1984).

2.7.3 Seeps

Fourteen seeps were identified in the RI study area, and all were sampled. Sampling locations are shown in Figure ___. Seep and probe water quality were compared to Washington State Board of Health standards for maximum contaminant levels (MCLs) for groundwater (WAC 248-54-175; WDSH 1983) and concentrations of constituents normally found in groundwater in King County (Turney, 1986). Groundwater standards were considered more appropriate for seep and probe water than surface water standards because seeps are thought to represent groundwaters that have recently surfaced.

Jeff: please provide figure showing sampling location or show locations on a previously cited figure.

Provide complete citation for Turney, 1986 in the reference.

Compare seep water quality to MTCA method B groundwater standards.

All parameters were within normal ranges, below applicable standards, or below detection limits, except for pH and COD. The ph values ranged from acidic to neutral, i.e. 5.2 to 7.0. The acidity could be accounted for by naturally occurring organic acids arising from leaf litter or other decomposing organic matter that was observed in the vicinity of the seeps. Three samples (SP-A, SP-C, and SP-H) had relatively high COD values. These values may be the result of iron sulfides or other species generated naturally.

One seep sample, SP-F, showed detectable levels of volatile organics (benzene, 14 ppb; toluene, 10 ppb; and ethylbenzene, 66 ppb). The semivolatile organic 1,2,3-trichlorobenzene (12 ppb) was also detected in this sample. A gas station was formally operated on the property adjacent to this sampling location. These compounds may be attributable to contamination from past activities on the adjacent property.

No contamination attributable to the landfill was found in the seeps. This result was expected because of the distance from the landfill to the seeps, the lack of a groundwater flow path connecting them, and the magnitude of dilution that would occur between the landfill and the seeps.

2.8 LANDFILL GAS INVESTIGATIONS

Decomposition of waste in a landfill produces gases. Most of the landfill gas is methane, which is colorless, odorless, and non-toxic. The danger associated with methane is the potential for fire or explosion. However, contaminants that are potentially hazardous to health may be found in landfill gas at low concentrations, depending on the nature of the materials disposed and decomposition.

The remedial investigation collected data on the landfill gas. The Landfill Gas Technical Report (Seattle, 1988), summarizes the installation of gas monitoring wells and provides an assessment of the effectiveness of the gas extraction wells in controlling off-site migration of landfill gas. It also summarizes studies characterizing the composition of on-site and off-site gases and identifying the potential subsurface migration pathways for gas in the vicinity of the landfill.

The Air Quality Technical Report (Seattle 1988), describes studies conducted to assess the influence of landfill gas emissions on ambient air in the Midway vicinity.

Jeff: Please provide complete citations for the two Seattle, 1988 reports.

2.8.1 GAS CONTROL SYSTEM

The gas control system is made up of on-site gas migration control wells installed around the perimeter of the landfill and off-site gas extraction wells installed in the areas where subsurface gas was discovered.

The purpose of the on-site migration control wells is to prevent gas migration from the landfill and pull back off-site gas. The purpose of the off-site gas extraction wells is to quickly remove gas that has previously migrated off-site.

Off-site probe monitoring will continue indefinitely as a means of checking the effectiveness of the "vacuum curtain" established around the site by operation of the migration control wells.

Approximately 150 off-site monitoring probes, 17 off-site gas control wells, and 78 on-site migration control wells have been installed by the City and Ecology to monitor and control the off-site migration of gas from the Midway Landfill.

2.8.1.1 On-Site Gas Migration Control Wells

Thirty-seven Phase I migration control wells (wells 1 through 37) were installed in the waste on 100- to 200-foot centers around the perimeter of the landfill (See Figure 2-14). Due to the operational limitations of the Phase I migration control wells in preventing off-site migration of landfill gas, 41 additional Phase II migration control wells were installed between November, 1986 and December, 1987. Phase II wells are shown on Figure 2-14 as PA and PD wells.

Jeff: Provide figure 2-14. Show all wells. Identify those abandoned or no longer in use.

The current on-site migration control system is doing an effective job in eliminating off-site landfill gas migration. The addition of the final cover has allowed for increased flows from both in-waste wells and in-soil wells. This will help decrease the concentrations of methane gas that have accumulated off-site over time. In the future it may be necessary to install additional wells to improve control on gas migration.

2.8.1.2 Off-Site Gas Extraction Wells

It became apparent after a few months of operating the on-site migration control wells that the reservoir of off-site gas was not going to be pulled back to the landfill quickly. The gas in the soil in residential neighborhoods was a concern because of its potential for migrating through basements and structure slabs into the houses. It was decided that off-site extraction wells would be installed. The first five off-site control wells created a negative pressure in the soil underneath the structures, which prevented further seepage of gas into the structures. Based on the performance of these wells, the City installed ten more control wells, nine in the neighborhood east of the landfill and one directly west of the landfill.

At the same time, the Washington Department of Ecology began installing two larger off-site control wells in the same vicinity. After observing the ability of the larger Ecology control wells to remove large quantities of gas from an extensive area, the City of Seattle utilized the design of the Ecology wells to install five additional wells, These wells removed pockets of deep gas remaining northeast and south of the landfill. Six off-site control wells remain in operation: C6, C7, C12, C13, C16, and C17. Their locations are shown on Figure 2-15.

Jeff: Provide figure 2-15. Show all wells. Identify those abandoned or no longer in use.

The off-site control wells installed in the vicinity of the Midway Landfill have proven successful in protecting nearby structures from the seepage of migrated landfill gas. The larger off-site control wells have also been successful in reducing the concentrations of methane gas that has migrated from the landfill to form large reservoirs off-site.

As a result, many off-site control wells have been shut down after extremely low methane concentrations were recorded in nearby monitoring probes over a period of several months. Because of the influence of the on-site migration control system, it is not expected that landfill gas will return to these areas. However, the probes will continue to be monitored and the control wells will be restarted if any significant rise in methane levels is detected.

2.8.2 GAS MONITORING PARAMETERS

2.8.2.1 <u>On-Site Monitoring Parameters</u>

The on-site gas migration control system includes wells installed in waste and wells installed in native soil on the landfill perimeter. The major constituents of the gas in these wells are monitored carefully to determine the amount of anaerobic and aerobic decomposition taking place in the surrounding or nearby waste.

Methane gas and carbon dioxide are produced in the anaerobic decomposition of organic materials. Carbon dioxide, water, and heat are produced in the aerobic decomposition of organic materials. It is particularly important to monitor the temperature of the gas stream in the migration control wells installed in waste. Excessive heat produced in aerobic decomposition can cause the decomposing waste to combust spontaneously.

The in-waste wells at the Midway Landfill are monitored weekly for the following parameters:

- Combustible gas percentage
- Oxygen percentage
- Carbon dioxide percentage
- Static pressure
- Temperature
- Velocity of gas stream in well

See Figure 2-14 for location of gas wells installed into the waste.

Jeff: figure 2-14 should identify the in-waste wells.

2.8.2.2 Off-Site Gas Monitoring Parameters

The extent of off-site landfill gas migration can be determined by monitoring certain parameters in the off-site monitoring probes and off-site extraction wells. The locations of the off-site gas monitoring wells are shown in Figure 2-15. Measurements routinely taken at off-site monitoring probes and off-site control wells include:

- Combustible gas (percent, parts per million, or percent lower explosive limit [LEL])
- Oxygen (percent)
- Static pressure (vacuum in the well)
- Velocity (control wells only

The following compounds are measured periodically only in control wells:

- Carbon dioxide (percent)
- Hydrogen sulfide (parts per million)

Gas velocity in control wells is converted mathematically to a flow measurement. The static pressure and flow measurements are used to evaluate the control well's relative sphere of influence, and samples of the discharge are analyzed periodically for volatile organic compounds and priority pollutants.

2.8.3 GAS CHARACTERIZATION

The gas characterization study conducted as part of the remedial investigation (Appendix E of the Landfill Gas Technical Report, Seattle, 1988) summarizes the findings of several studies intended to characterize the chemical composition of subsurface gases in the vicinity of the Midway Landfill. These studies compare on-site gas from within the Midway Landfill with off-site subsurface gas to evaluate the possibility that substances found in the on-site landfill gas may have migrated off-site.

Jeff: please provide the complete citation for the Seattle, 1988 Landfill Gas Technical Report.

The objectives of the gas characterization study were:

- To identify chemical components present in on-site subsurface landfill gas samples collected from:

    - On-site gas extraction wells
    - Pre-combustion flare gas (flare inlet gas)

- To identify a list of on-site gas contaminants comprising a potential "fingerprint" of Midway Landfill gas

- To identify chemical components present in off-site subsurface gases

- To evaluate the relationship between on-site gas composition and off-site gas composition

The subsurface gas collected from the on-site gas extraction wells and flare manifolds contain a wide variety of substances. The compounds found most frequently and in the highest concentrations in the on-site subsurface gas included ethylbenzene, vinyl chloride, total xylenes, toluene, and benzene. The maximum concentrations of these compounds were in the low parts-per-million (ppm) range. The toxic inorganic gases hydrogen sulfide and carbon monoxide were also reported present on-site in the low parts-per-million range. Hydrogen cyanide was not detected in on-site gas.

The association of volatile organic compounds ethyl-benzene, benzene, toluene, total xylenes, and styrene, referred to here as the "BTX group," was judged to comprise the "fingerprint" of the volatile organic compounds that are found in landfill gas. These compounds were found most frequently and in the highest concentrations on-site. Other volatile organic compounds were found less frequently and in lower concentrations, generally in the parts-per-billion range.

Mapping of these "finger print" gas components suggested that off-site migration of at least some on-site gas contaminants has occurred, potentially in all directions away from the Midway Landfill. However, off-site concentrations of the five BTX-group compounds appear to be attenuated with increasing distance from the landfill. No BTX-group compounds were found more than 2300 feet from the landfill perimeter.

The extent of gas migration is shown in Figure 2-16.

Jeff: please provide figures of extent of gas migration for selected years since monitoring and extraction began.

Vinyl chloride was frequently associated with the BTX-group compounds in on-site subsurface gas. During sampling of off-site gases, vinyl chloride was found at only two of the gas monitor probe locations, both south of the landfill. ****** Jeff: please identify these two probes. ****** In a separate study, vinyl chloride was also found at concentrations of up to 1-3 ppm at other locations to the east and south of Midway Landfill in the subsurface gas samples collected from off-site gas control wells. ****** Jeff: please identify these probes too. ******

Several volatile organic compounds were detected in subsurface gas samples collected west of the landfill at off-site gas monitoring probe completions 88-S and 88-M, which are adjacent to a wetland area. These compounds may be associated with materials present in the wetland. ****** Jeff: has the on-going gas monitoring verified this hypothesis? ******

2.8.4 GEOLOGIC PATHWAYS FOR GAS MIGRATION

The two objectives of this study were:

- o To identify subsurface geologic pathways in the area surrounding the landfill through which landfill gas might potentially migrate off-site; and,
- o To compare these potential pathways with known concentrations of off-site gas to construct a hypothesis of how the gas reached the areas in which it was found.

Jeff: please provide citation for this study.

To identify potential geologic pathways for gas migration, aquifers underlying the study area were examined for evidence of unsaturated zones. Unsaturated zones in the aquifers underlying the Midway Landfill vicinity were mapped, using hydrogeologic cross sections and potentiometric surface data. Potential gas migration pathways were then identified by correlating hydrogeologic cross sections and noting connections between the landfill, the unsaturated zones, and locations off-site where the ground surface intercepts the unsaturated zones. At these locations gas potentially could escape to the atmosphere.

Potential sources and receptors were reviewed in relation to the potential pathways. Potential sources of subsurface gas include the landfill, surface peat bogs, buried peat bogs, lake beds, and other buried wetland areas, small undocumented landfills, and natural gas pipeline leaks. The possible receptors are homes and business structures located at the points where migration routes reach the ground surface.

The next phase of the analysis involved comparing the potential gas migration pathways with known gas concentrations off-site. This was done using gas concentration isopleths that illustrate the distribution of subsurface gases by plotting data points from gas extraction wells and monitoring probes.

Figure 2-17 shows the extent and thickness of the landfill-connected gas migration pathways and includes the elevations above mean sea level (AMSL) of both the potentiometric surface and the upper surface of each aquifer. The connected zones are generally at or above the elevation of the bottom of the landfill (255 feet AMSL). The landfill's upper surface is approximately 350 to 390 feet AMSL.

Jeff: please provide figure 2-17.

The unsaturated zones form a system of potential gas migration pathways that of transmit landfill gas away from the landfill. These interconnected zones are located mainly to the east and southeast of the landfill, with a small but notable lobe to the northwest. These pathways appear to occur almost exclusively within the upper gravel aquifer. The aquitards overlying the upper gravel aquifer and the sand aquifer appear to severely limit the vertical migration of gas between aquifers. In reality, these aquitards may have as high concentrations of gas as the aquifers, however, gas moves through an aquitard at a rate 2 to 6 orders of magnitude slower than it moves through a more permeable aquifer. For this reason, the aquitards release smaller quantities of gas to an overlying sediment or to the ground surface.

The unsaturated portions of the upper gravel aquifer are the major gas migration pathway to the east and southeast of the landfill. These pathways allow gas to migrate up to 2600 feet from the landfill. This affected area extended from I-5 to the east of Military Road. See Figure 2-16 for extent of gas migration.

Jeff: do you think it would be valuable to provide figures and a discussion of the historical changes to the extent of gas migration?

The unsaturated portion of the upper gravel aquifer has been the major gas migration pathway to the south of the landfill allowing gas to migrate up to 2000 feet from the landfill, as shown in Figure 2-17. However, the upper gravel aquitard appears to have been impermeable enough to limit gas movement to the ground surface in this area. The affected area extends from the landfill to South 259th Place between 29th Avenue South and I-5.

The unsaturated portion of the upper gravel aquifer also appears to be a gas migration pathway for a short distance west of the landfill. The upper gravel aquitard in this area appears to have been impermeable enough to limit gas movement to the ground surface. The area affected was from the landfill to Highway 99, between South 249th Street and South 252nd Street.

The unsaturated portion of the upper gravel aquifer may have been a gas migration pathway for a limited distance northwest of the landfill. However, the upper gravel aquitard and an overlying perched water table appear to have limited gas movement to the ground surface. The area affected was from the landfill north to about South 244th Street, between Highway 99 and 30th Avenue South extended.

Jeff: the figures showing extent of gas migration should show the streets and highway mentioned above.

2.9 AMBIENT AIR QUALITY

Initial studies of Midway Landfill gas emissions were conducted by the University of Washington (Larson and Wineman, 1985) prior to the Midway Landfill Remedial Investigation. The initial studies included on-site and off-site monitoring to compare ambient air quality at locations upwind and downwind of the landfill.

Jeff: please provide citation Larson and Wineman, 1985 in reference section.

The subsequent remedial investigation air quality monitoring program was designed to follow the general procedures outlined in the earlier University of Washington studies, with some modifications to the program based on discussions involving the EPA, the Washington State Department of Ecology, the Puget Sound Air Pollution Control Agency, and the City of Seattle. A detailed discussion of the air quality monitoring program is contained in the Midway Landfill Remedial Investigation Air Quality Technical Report (Seattle, 1988).

Jeff: please provide complete citation Seattle 1988 in reference section.

The following studies were conducted as part of the air quality investigation:

- Upwind/downwind/off-site ambient air sampling to determine whether the landfill is a measurable source of contaminant emissions.
- Stagnant air sampling to determine whether these contaminants accumulate under stagnant conditions.
- Flare sampling to assess emission rates from the two temporary on-site landfill gas flares.
- Meteorological monitoring to document meteorological conditions on the site during remedial investigation activities.
- Air quality dispersion modeling to predict ambient air quality impacts during typical and worst-case meteorological conditions in the Midway vicinity.
- Miscellaneous air quality monitoring of potential landfill gas emissions during drilling and installation of leachate monitoring wells and during trenching and installation of on-site gas extraction wells to determine whether these activities resulted in adverse impacts to worker health and safety or to ambient air quality.

2.9.1 EXISTING CONDITIONS

The landfill occupies a 60-acre site approximately 15 miles south of the City of Seattle. The site is bounded on the east by Interstate 5 and on the west by Pacific Highway Sough (State Highway 99), both of which are major transportation corridors and known sources of air pollution caused by vehicle emissions.

Prior to the start of the air sampling program, most of the landfill had been capped with approximately 6 to 24 inches of a silt/sand material. Six to twelve inches of clay had also been placed on some parts of the landfill surface, especially around the on-site gas extraction wells. An on-site gas extraction system had been installed that consisted of gas extraction wells, motor blowers, and two temporary gas flare systems. These improvements could be expected to have substantially reduced or eliminated potential gas emissions from the general landfill surface; however, the temporary gas flares were recognized as potential sources of contaminant emissions to the ambient air in the vicinity of the landfill.

2.9.2 AMBIENT AIR QUALITY SAMPLING

To measure the gaseous emissions from the surface of the landfill, ambient air was sampled upwind, downwind, and off-site relative to the landfill.

The purpose of the project was to develop a wind-driven air dispersion model and identify contaminants present in ambient air for comparison with contaminants present in raw landfill gas. The goal was to use upwind/downwind/off-site data to determine the emission rates for various chemical compounds escaping as gases from the landfill site. These emission rates could be used in a model to predict the ambient air concentrations of contaminants attributable to emissions of landfill gas at any location in the surrounding community.

The sampling protocol is described in the Final Project Work Plan (Black & Veatch, 1986a) and the Sampling and Analysis Plan (Black & Veatch, 1986b).

Jeff: please provide complete citations of Black & Veatch, 1986-a&b in reference section.

Twenty-two of the 38 target volatile organic compounds were found. Three of these (methylene chloride, styrene, and acetone) are suspect because they were found in laboratory blanks on several sample rounds.

In order to place the air quality sampling results in perspective, the maximum and mean observed concentrations for each volatile organic compound at any station were compared with Commonwealth of Massachusetts Acceptable Ambient Levels (MA-AALs) provided by the Department of Ecology (Commonwealth of Massachusetts, June 1985). The MA-AALs are the most comprehensive ambient air quality standards available for volatile organic compounds and other air contaminants.

Comparisons of upwind, downwind, and off-site concentrations of the target USEPA VOCs led to the conclusion that the surface of the Midway Landfill is not a source of measurable emissions. Based on the data, measured contaminant concentrations in the atmosphere at any point in the vicinity of the Midway Landfill represent a combination of the background ambient air concentration and the contributions of emissions sources in the immediate area that are not attributable to the landfill.

The fact that 1) most of the target compounds were found upwind and/or off-site as well as downwind, 2) upwind and/or off-site concentrations were equal to or exceeded downwind concentrations, and 3) observed upwind/downwind/off-site relationships were not consistent across wind directions provided evidence that Midway Landfill is not the source of the target compounds.

Samples collected at stations located near the highways, particularly Interstate 5, frequently had higher contaminant concentrations than other sampling stations, including stations downwind of the Midway Landfill. The two highways in the area, therefore, appear to be the most likely sources of the observed concentrations of many compounds detected during the upwind/down/wind/off-site ambient air sampling program.

The two highways are likely to be sources of many of the aromatic hydrocarbons known to be present in vehicle exhaust gases.

The measured chlorinated compound concentrations detected in ambient air samples are likely to be attributable to background values for the area; they do not appear to be influenced by any observed local source, including the landfill.

The mean concentrations of VOCs recorded are very similar to background concentrations of VOCs measured in typical urban areas.

2.9.3 FLARE SAMPLING PROGRAM

Two temporary gas flares were sampled by TRC Environmental Consultants between June 15 and June 19, 1987. The objectives were to determine the rate and composition of emissions from the flares and to estimate the flares' destruction and removal efficiency (DRE), i.e., the degree to which combustion destroys trace organic chemicals present in the landfill gas. The flares were sampled at the inlet and at a point near the top of the flame. Samples were analyzed for volatile organic compounds, and hydrogen cyanide, hydrogen chloride, hydrogen sulfide, carbon dioxide, oxygen, and several additional organic compounds.

The results of flare emissions testing performed by TRC indicate the presence of relatively low but detectable quantities of contaminants of concern in the flare emissions. It is important to recognize that the accuracy of the flare was greatly compromised by the methodological difficulties encountered in sampling the temporary flares. It is likely that destruction and removal efficiency (DRE) values were underestimated for most compounds. This is based on the observation that the majority of the identified methodological biases tended to lead toward underestimation of DRE values.

Jeff: please provide a description of the temporary use of the temporary flares. I assume they are no longer in use. When was use discontinued and what was used to replace the flares?

2.9.4 AIR QUALITY MODELING

The SHORTZ and POSTZ air quality models were used by TRC Environmental Consultants to develop the air dispersion model for Midway Landfill. The methodology is described in the Midway Landfill Air Quality Technical Report (Seattle, 1988).

Based on flare sampling and air dispersion modeling results, benzene was the compound predicted most likely to occur in the greatest off-site ambient air concentrations attributable to Midway flare emissions. Benzene's computed peak 24-hour ambient air concentration, however, is only 4-5% of the observed mean background ambient concentrations for the vicinity of the Midway Landfill and 2% of the United States mean concentrations. The highest predicted annual average concentration is only 1% of typical U.S. annual mean concentrations.

3.0 LANDFILL CLOSURE

3.1 SCOPE AND PURPOSE

The Seattle Engineering Department, Solid Waste Utility, **(Jeff; please provide appropriate Seattle Public Utility name if it has changed from SED,SWU)** has implemented cleanup action and closure of the Midway Landfill. The cleanup and closure represents the final phase of closure construction and post-closure operations. Earlier phases of the process included:

- Detailed field investigations of air, surface and groundwater quality;
- Development of engineering alternatives to mitigate potential adverse impacts; and,
- The preparation of a formal environmental impact statement which evaluated these alternatives under the guidelines of the Washington State Environmental Policy Act (SEPA).

The Final Environmental Impact Statement (FEIS) for the Midway Landfill was issued on May 28, 1986.

In addition to the primary state and county solid waste regulations, MTCA, and CERCLA requirements, a number of other federal, state and local laws and regulations have jurisdiction over the construction and operation of the cleanup and closure program. Table 3-1 lists those licenses, permits, and approvals which were required for closure and post-closure.

TABLE 3-1. Required Permits, Licenses and Approvals

(Jeff: is this a complete list? Please add columns to show date for each permit and identify those permits not obtained and give reason(s) why they were not obtained.)

Permit/License	Approval Authority
• Section 10/404(b) Permit:	U.S. Army Corps of Engineers
• Water Quality Certification	Washington State Department of Ecology
• Short-Term Exception to Water Quality:	Washington State Department of Ecology
• National Pollutant Discharge Elimination System (NPDES) Permit:	Washington State Department of Ecology
• Permit for Discharge of Wastewater to a Publicly Owned Treatment Plant (POTW):	Washington State Department of Ecology
• Superfund Approval:	U.S. Environmental Protection Agency and Washington state Department of Ecology
• Plan and Specification Approval:	Washington State Department and Seattle-King County Department of Public Health
• Hydraulic Project Approval:	Washington State Departments of Fisheries and Game
• Construction Permit:	Washington State Department of Transportation
• Archaeological Clearance:	Washington State Office of Archaeology and Historic Preservation (SHPO)
• Permission for Access and Construction:	Washington State Department of Parks and Recreation
	Puget Sound Air Pollution Control Agency
• Notice of Construction:	Seattle-King County Department of Public Health
• Completion and Recurrent Inspection:	King County
• Shoreline Management Substantial Development Permit:	King County Auditor
• Site Registration:	City of Kent
• Grading Permit:	City of Kent
• Building Permit:	METRO
• Waste Discharge Permit:	King County
• Flood Control Zone Permit:	City of Kent
• Drainage Permit:	City of Kent
• Street Use Permit:	Seattle-King County Department of Public Health
• Solid Waste Permit (Closure):	City of Des Moines
• Street Opening Permit:	City of Des Moines
• Land Clearing, Filling, or Grading Permit:	City of Des Moines
• Building Permit	

3.1.1 RELATIONSHIP CLOSURE PLAN TO OTHER PLANS

The Midway Landfill Cleanup Closure Plan is the culmination of the overall planning and evaluation process for the final cleanup and closure of the landfill site. Previous engineering and planning documents completed by the Solid Waste Utility **(SPU ???)** included:

- o Midway/Kent Highlands Sanitary Landfills Description of Alternatives for Closure Plans, 1983
- o Draft Environmental Impact Statement Midway Landfill Closure Plan, 1985
- o Final Environmental Impact Statement Midway Landfill Closure Plan, 1986

These engineering and planning efforts along with extensive input from regulatory and jurisdictional agencies and the public form the basis for the preparation of this Cleanup Closure Plan.

3.2 FINAL GRADING/SITE DEVELOPMENT

3.2.1 DESIGN CONCEPT

The final grading plan was designed to control surface water infiltration. The stability of the landfill and adjacent properties was also considered.

Minimum slopes selected to facilitate runoff range from two to five percent and a maximum slope of 4:1 horizontal to vertical; (25 percent) was used for the fill slopes. These grades are designed to permit drainage during the settlement of the fill, which may be as great as 15 percent.

(Jeff: describe any settlement that has occurred, if any, and provide settlement magnitude. Provide statement if there is no settlement).

3.2.2 CONSTRUCTION REQUIREMENTS

2.3.1 General. Figure 3-1 outlines the final grading plan for the site. Filling of the South and Middle Ponds was necessary to avoid pumping of on-site surface water runoff. The most substantial site filling occurred in the South Pond so that surface water runoff currently collecting there would flow to the north. The Middle Pond and the northwestern section of the property received about 10 to 20 feet of fill so that surface water runoff collecting there would drain to the north and west. In addition, the southeast corner of the site was filled to provide a minimum slope of 5 percent and promote surface water runoff from this corner. An estimated 370,000 cubic yards of fill material was needed to bring the landfill to final grade prior to construction of the final cover system. All fill material used was clean soil. No solid waste material was utilized for filling.

(Jeff: Provide Figure 3-1: final grading plan. Show direction(s) of surface water flow routes on final grading plan. Note also that a site grading plan, figure 3-5, is identified in section 3-5. There may be a redundancy, in which case only one grading plan figure is

necessary.)

Access to this site is maintained permanently at the existing access road form Highway 99 as shown on Figure _____(no number). Upon completion of construction, the site was fenced and a buffer with landscaping in some areas was installed on the east, south and north segments of the property.

(Jeff: Figure ______(no number). Is access road shown on previous figure(s) drafted by Parametrix in the original CAP? If not, which figure will you have your contractor show this information?)

3.3 LEACHATE MANAGEMENT PLAN

3.3.1. DESIGN CONCEPT

The generation and potential off-site migration of leachate from the Midway Landfill is one of the two most serious environmental impacts caused by the Midway Landfill. Leachate generation at the Midway Landfill originates from two major sources:

(1) Infiltration of precipitation falling directly on the landfill, and;

(2) Inflow from off-site surface water runoff.

The total annual leachate generation is approximately 48 million gallons.
(Jeff: is this volume accurate for the past few years? Show a table of annual volume changes in leachate collection if volumes fluctuate annually.)

The design concept focuses on the control and reduction of the amount of leachate being generated. Key elements of this leachate management plan include:

- Elimination of direct surface water discharges into the landfill.
- Development of an effective on-site surface water management plan.
- Reduction of the infiltration of precipitation into the landfill through the development of a final cover system which includes a low permeability layer.
- Collection, treatment, and disposal of leachate that may otherwise emerge as seeps on the surface at the toe of the landfill side slopes.
- Periodic monitoring of ground and surface water for efficiency of leachate breakouts and subsurface migration.

3.3.2 PLAN COMPONENTS

The leachate management plan for the Midway site is composed of four elements:

- Final Cover System
- Surface Water Management Plan
- Compliance Monitoring Plan
- Contingency Plan

All of these elements, with the exception of the Contingency Plan were implemented with the final closure of the site in 19____. **(Jeff: provide date).**

The overall performance of this plan is estimated at approximately 98 percent. That is, 98 percent of all leachate currently being generated as a result of infiltration of precipitation on the site or directly discharging into the landfill will be eliminated. It is estimated that surface water flow onto the landfill has been reduced from the 16 million gallons annually prior to closure to 0 gallons annually after closure. Surface infiltration will be reduced from the estimated 32 million gallons to under 2 million gallons annually. **(Jeff: please state source of "surface infiltration". Are these predicted volume reductions accurate?)**

3.3.3 FINAL COVER SYSTEM

Approximately 32 million gallons of precipitation infiltrates the landfill annually to produce leachate. To reduce this leachate generation source, the site is covered with a multi-layered low permeability soil cover cap designed to reduce the potential infiltration. This cover soil will be integrated with other engineered materials to produce a cover system which will reduce potential leachate production from the current estimated 32 million gallons to under 2 million gallons annually.

Several cover options were evaluated. The recommended cover is a multi-layered soil cover described in Section 3.4

3.3.4 SURFACE WATER MANAGEMENT PLAN

Currently no outlets exist for surface water entering the Midway Landfill. This condition has allowed infiltration of approximately 32 million gallons of precipitation and permits approximately 16 million gallons of surface "run-on" to discharge into the site. A surface water plan was necessary to eliminate this "run-on" as well as manage the increased runoff from the final cover system. A critical element of this surface water plan is the development of an outlet system which will successfully remove drainage from the landfill without causing adverse impacts to off-site properties and drainage systems. The details of both the onsite and off-site drainage elements are discussed in Section 3.5.

3.3.5 COMPLIANCE MONITORING PLAN

The performance of the Leachate Management Plan will be demonstrated through a comprehensive surface and groundwater monitoring program. This program is a part of the post-closure and monitoring plan described in Section 4.0. The monitoring program will identify changes in surface and ground-water quality resulting from closure and provide the City, the Seattle-King County Health Department, and the Department of Ecology a mechanism to evaluate performance of the closure elements.

3.3.6 CONTINGENCY PLAN

The leachate management plan for Midway is a remedial action to eliminate or substantially reduce the impacts of leachate generation and migration. It is possible that some aspects of this plan may not be totally successful in preventing off-site leachate migration; therefore, a contingency plan is required which can supplement these initial remedial measures. Contingency plan concepts are outlined in Section 5.0.
(Jeff: is it possible to provide a statement here that states that none of the contingency plans have been evoked to date since closure?)

3.4 LANDFILL COVER SYSTEM

3.4.1 DESIGN CONCEPT

The principal objective of the landfill cover is the reduction of surface infiltration of precipitation. Other functions of the cover include the reduction of landfill gases escaping from the landfill surface, erosion protection, and improvement of aesthetic appearance.

Several final cover options were evaluated, including the system required under the Minimum Functional Standards (MFS).

The selected cover is a multilayered soil cover which employs a barrier layer of lower permeability material ($1x10^{-7}$ cm/sec) constructed beneath a high permeability ($1x10^{-2}$ cm/sec) drainage layer. The barrier layer will block the majority of surface infiltration from entering the landfill. A schematic of this proposed cover system is shown on Figure 3-2. The final cover system is described in detail in Table 3-1.
(Jeff: please provide Figure 3-2.)

The drainage layer is constructed above the barrier layer. The drainage layer captures and diverts surface infiltration to the edge of the landfill. Surface water collected in this drainage layer would be collected in the peripheral storm drainage system. This water is discharged with other site storm drainage because it is uncontaminated surface water infiltration.

Additional elements incorporated in the final design include a toe seep collection system and a drainage layer. The toe seep collection system is a leachate collection layer constructed beneath the final cover to facilitate the collection of any lateral seepage of leachate near the sides or toe of the landfill.

(Jeff: what is this the purpose of the additional drainage layer element? Is the additional drainage layer element an integral part of the toe seep collection system? If so, please re-draft above paragraph to eliminate confusion.)

3.4.2 CONSTRUCTION REQUIREMENTS

Construction of the final cover system followed the initial site grading and installation of the surface water management systems. The site surface grading and part of the drainage facilities were installed in 1987. The final cover was installed in the spring and summer of 1988.

The final cover will require periodic inspection and maintenance to correct any problems resulting from erosion and differential landfill settlement. Maintenance will include regrading of localized depressions and repair of any cracks in the barrier layer or channels eroded by surface water runoff. Bare areas will require reseeding to maintain the vegetative cover. These inspections and maintenance requirements are detailed in the post-closure operations and maintenance manual. **(Jeff: provide citation for the O&M manual.)**

Table 3-1 Components of Multi-Layer Landfill Cover System.

Name	Criteria[1]	Purpose	Depth (in)	Volume[1] Req'd (CY)
Top Soil	Organic Loam	Support vegetation which increases evap-transpiration, protect soil from erosion, and improve appearance; increase moisture storage capacity of cover; provide biologic treatment of odorous landfill gases.	6	43,500
Filter Layer	In accordance with accepted criteria[2]	Prevent migration of soil fines into the drainage layer.	6	43,500 (261,360 SqY geotextile*)
Drainage Layer	$K \geq 10^{-1}$cm/sec	Provide a pathway to the storm drains system for precipitation that has infiltrated through the overlying topsoil.	18	130,500
Barrier Layer	Top 4 inches $K \leq 10^{-7}$cm/sec	Restrict the downward percolation of water from precipitation into the waste; required permeability of 10^{-7} cm/sec may necessitate bentonite admixture.	12	87,000
Toe Seep	$K \geq 10^{-2}$cm/sec applied on slopes >25%	Intercept leachate from within the landfill that may otherwise break out on the side slopes and provide a pathway to the toe seep collection system.	6	11,000

[1] Based on final cover area of 54 acres.

[2] Cedergren, 1967.

* Geotextiles may be used to replace or supplement soil in the filter layer.

***** Jeff: please update this table as necessary for as built conditions. *****

3.4.3 CONSTRUCTION IMPACT MITIGATION

(Jeff: please provide this section.)

3.4.4 ALTERNATE COVER SYSTEMS

Other methods and materials for the landfill cover options were considered which could be utilized to achieve an equivalent permeability of 10^{-7} cm/sec. These options included:

- o Asphalt (such as hydraulic asphalt concrete, soil asphalt, or sprayed-on asphalt linings).
- o Flexible membrane liners (FML).
- o Soil sealants.

The evaluation criteria for the landfill cover options included: permeability, constructability, compatibility with future land use, long-term maintenance requirements, and costs.

Of these alternative systems, the FML was considered to be potentially applicable for use at the Midway site. The disadvantages to the use of a FML include:

- o Installation and incompatibility problems with other components of landfill systems, for example, the toe seep collection systems, surface water control systems, and landfill gas wells.
- o Potential tearing due to differential settlement.
- o Difficulties in repair during inclement weather.
- o Potential problems associated with final land uses.

3.5 SURFACE WATER MANAGEMENT PLAN

An effective surface water management program is needed to eliminate the direct discharge of on-site runoff produced as a result of the installation of the final cover system. In addition, the surface water management program needs to address the following requirements:

- Improve the quality of runoff discharged from the site.
- Controls for erosion and siltation.
- Limitations of any off-site discharge of runoff to contaminant concentration levels no greater than existing peak flows in any off-site receiving stream.

The overall plan required construction of three separate storm drainage systems to remove runoff from within and on the landfill and to safely discharge it to the west. These systems are termed the I-5/East, Onsite Detention, and Highway 99-West discharge systems. The design concept utilizes a large onsite detention basin (approximately 31.5 acre-ft capacity) to detain and release collected runoff.

A westerly discharge route for storm water was chosen because it would comply with King County and City of Kent drainage ordinances, ease of obtaining necessary permits, and constructability within one year.

This system consists of an approximately 5,200-foot long pipeline from the on-site detention basin west across Highway 99 and along the 250th Street South corridor. The pipeline will discharge into the North Fork of Smith Creek. **(Jeff: please show pipeline route on a previous figure.)**

The Midway Landfill presents a unique situation, in that there was no discharge of storm water from the site. Moreover, if the ponds on site overflowed during a storm and if there was natural surface drainage to convey the storm water off-site, the surface waters would flow westward toward Puget Sound via Smith Creek rather than east toward the Green River. King County does not consider the Green River a natural discharge point for run off from the landfill and diversion of surface water from the landfill to the Green River would not be authorized by King County.

Extensive engineering investigations were conducted to evaluate on-site systems and off-site Puget Sound discharge alternatives. Principal alternatives considered were:

1. Puget Sound discharge with off-site detention.

2. Puget Sound discharge with on-site detention.

3. Puget Sound discharge with no detention.

4. Direct pipeline to Puget Sound.

Alternative 2 was selected as the preferred alternative. Site studies evaluated several pipeline routes and discharge points west of Highway 99. Detailed recommendations are presented in the final EIS and in the addendum to the final EIS. The detailed recommendations are summarized in the following sections.

3.5.1 RECOMMENDED PLAN

Figure 3-3 outlines the proposed Surface Water Management Plan for the Midway Landfill.

****** Jeff ****. Please provide figure 3-3, if appropriate. I think this reference to figure 5-1 is a carry over from a Seattle document or Ecology in-house drafts. I do not know if this an existing figure or not. If you locate this figure then please send me a copy for me to evaluate whether or not it is appropriate to show this figure. I think it would be**

illustrative to show a discharge route map.

3.5.2 I-5/EAST DRAINAGE SYSTEM

The drainage facilities to intercept and reroute runoff from I-5 and the area west of I-5 will consist of a detention basin, pump station, force main and gravity sewers. The pump station is a motor-driven unit equipped with emergency power capabilities. The pump station discharges to a pressure line extending southerly along the right-of-way of I-5. The line extends to a point where sufficient elevation is attained to allow gravity flow into an existing storm drain crossing westerly under I-5 and thence north to the detention basin. A new 24-inch diameter pipeline was constructed parallel to the existing 24 inch CMP on the west side of I-5. To reduce pump station requirements and to provide for emergency storage, a small basin adjacent to the freeway was developed as a detention basin. The existing culvert crossing and discharge manifold into the landfill was retained and modified for use as an overflow for emergencies.

3.5.3 DETENTION FACILITIES

The detention basin constructed for Midway landfill is located on property purchased by the City of Seattle immediately adjacent to the landfill. This allows control of the quality and quantity of surface water leaving the site. The basin is a bottom lined pond approximately seven acres in size with a storage capacity of 31.5 acre feet. The outlet of the basin is equipped with a sedimentation trap and an oil/grease separator. The design discharge from this basin under a 24-hour, 25-year storm is about 21 cubic feet per second.

3.5.4 HIGHWAY 99/WEST DISCHARGE ROUTE

Figure 3-4 outlines the westerly discharge pipeline for the Midway Landfill. The pipeline discharge from the detention basin extends westerly under Highway 99 and extends approximately 5,200 feet along the 250th Street corridor. The pipeline will discharge into the North Fork of Smith Creek. The pipeline varies in size from 24 to 36 inches in diameter and is equipped with a baffled outlet structure to dissipate energy at the outlet and to reduce erosion problems due to discharge velocity. The pipeline is located through an existing established area of the Cities of Kent and Des Moines.

***** Jeff: please provide figure 3-4 if it is not redundant to figure 3-3. ******

Utility easements were required for the pipeline location between South 248th Street and South 249th Place. Acquisition of one developed residential lot was required for this segment of the proposed alignment.

The pipeline discharges surface water flow to the North Fork of Smith Creek along the south boundary of South 250th Street where the existing channel crosses the established roadway. A baffled outlet structure was constructed to reduce discharge velocities and significantly reduce channel erosion. The channel of the North Fork of Smith Creek downstream of the point of discharge is well defined with no in-stream impoundments and is relatively inaccessible. Downstream improvements were not necessary because peak flows discharging to Smith Creek would not increase.

3.5.5 CONSTRUCTION AND OPERATION REQUIREMENTS

Construction of the components of the surface water management plan proceeded concurrently with site grading. The work was completed in late 1987. Construction sequencing of plan components was important to meet design criteria. For example, the detention basin and Highway 99 diversion pipeline was completed prior to any off-site discharge of runoff.

On-site portions of the surface water management plan also include a series of open channel drainage ditches and culverts. These elements were constructed around the periphery of the landfill and are shown on the site grading plan (Figure 3-5). An interim on-site system was constructed with preliminary grading in 1987. A final on-site system was completed with the installation of the final cover system in the summer of 1988.

** **Jeff: please provide figure 3-5, site grading plan, if it is not redundant to figure 3-1.**

Final closure is expected to result in an overall improvement in the quality of surface water runoff generated by the site. The landfill cover will facilitate runoff of surface water and will maintain complete separation from any potential leachate contamination. The detention basins, both on-site and west of I-5, will provide improved sedimentation controls and will greatly assist in removing nutrient and heavy metal loadings associated with urban storm water runoff.

Operation and maintenance of all storm drainage facilities constructed under the closure will be the responsibility of the City of Seattle. This will include the off-site pipelines, detention basins, and pump stations. Specific O&M requirements will be detailed post-closure operations plan completed in 19__.

****** Jeff: please provide citation for O&M plan. Give date. Give complete citation in reference list. ******

3.6 LANDFILL GAS MANAGEMENT PLAN

3.6.1 DESIGN CONCEPT

The landfill gas control system proposed for the Midway site is divided into three major systems: lateral migration control, odor control, and off-site control.

3.6.2 LATERAL MIGRATION CONTROL SYSTEM

The lateral migration control system captures the subsurface escape of landfill gas to surrounding areas. The control system is a series of wells drilled around the periphery of the landfill, both in refuse as well as native soil. The wells are pumped by vacuum pressure to collect and withdraw gas. Each well is connected to a manifold pipeline, which in turn is connected to a motor and blower assembly which provides the vacuum. The wells are individually controlled by valves to permit adjustment in withdrawal rates to maximize gas removed while minimizing fire hazards.

Figure 3-6 is shows the planned lateral migration control system. The actual number of wells and there locations were determined during installation. The control system was designed for flexibility and expandability. Individual well withdrawal rates were adjusted and additional wells were added as necessary.

****** Jeff: please provide figure 3-6. See also section 3.6.3 for horizontal gas trenches.**

Once collected, the gas is pumped to a specialized flare where it is mixed with air and burned to control odors and destroy reactive organic compounds. Each flare is equipped with a shielded combustion area to minimize visual impacts. The flares are equipped with an automatic flame restart and alarm mechanism to ensure consistent combustion. Emissions from the flares are monitored periodically to make sure contaminants are destroyed and that no emissions occur which violate air quality standards.

****** Jeff: please state monitoring schedule for flare emission testing. ******

The effectiveness of the gas migration control system is monitored by an extensive off-site monitoring program. This system consists of a series of off-site shallow and deep monitoring probes. The landfill gas monitoring program is described in Section 4.0.

3.6.3 ODOR CONTROL SYSTEM

Landfill odor will be controlled by extraction of gases. This system consists of gas extraction wells and horizontal trenches. The extraction system will augment the lateral migration control system as shown in Figure 3-6.

The collected gases are burned by the flare system.

3.6.4 OFF-SITE CONTROL SYSTEM

Results of monitoring programs conducted by the City of Seattle and Ecology revealed that gas had migrated off-site from the landfill. Gas concentrations above acceptable limits were found in several neighborhood homes and business structures. To prevent methane from reaching explosive concentrations, a number of off-site gas extraction wells were installed by the City of Seattle and Ecology beginning in January 1986. The locations of the off-site extraction wells and the extent of gas migration in 1986 are shown in Figure 6-7.

***** Jeff: please show array of off-site gas extraction wells and extent of off-site gas migration as of 1986. *****

Testing for combustible gas in homes and businesses, and data from probes in the vicinity of the extraction wells, indicate that they are successful in reducing methane levels.

***** Jeff: I suggest a statement here on the present day success of gas elimination from off-site structures. *****

The gases at the off-site wells cannot be burned because these wells are located in commercial and residential areas. Carbon filters are used on the wells to absorb gas contaminants and reduce odors. Analysis of the discharge from these wells has shown that no health hazards are created by venting them to the atmosphere.

***** Jeff: please provide citation for the no health hazard determination for the off-site gas wells ******

3.6.5 EXISTING ON-SITE SYSTEMS

In September 1985, the City of Seattle began installation of a portion of the on-site migration control system as an emergency part of final closure. These wells (34 total) were connected by a manifold to temporary motor blowers and flares. The system has been in continuous operation since January 1986, and based upon methane concentrations in probes around the periphery of the site, appears to be operating successfully.

There are two exceptions. Gas concentrations in probes along the southern and northwestern boundaries of the site do not appear to be dropping sufficiently. Additionally, extraction wells in the west and north perimeter require very extensive monitoring and control to prevent oxygen intrusion and potential fire hazards.

****** Jeff: do the conditions two exceptions mentioned above still exist? *****

The current on-site control wells are located on the site perimeter, drilled entirely in refuse and screened through the total depth of the well. Additional wells were installed on-site and in native soil near the site perimeter to control the potential fire hazard caused by air intrusion and to improve efficiency.

?

On-site well design were modified to allow gas extraction from shallow and deep levels in the landfill. Wells in native soil were designed to extract gas from soil strata with high gas concentrations. These modifications allow for higher gas extraction rates, reduce potential fire hazards, and improve the efficiency of off-site gas removal.

3.6.6 OPERATION REQUIREMENTS

Operation of the on-site and off-site gas control system will be the responsibility of the City of Seattle. City personnel are trained in the operation and maintenance of all facilities. A formal operation and maintenance manual is prepared for the motor blower and flare unit and specialized training provided to City staff prior to start-up.

Operation of the off-site control wells will continue until gas concentrations have been reduced to acceptable levels as defined by the monitoring requirements (Section 4). Only then will these wells be turned off. No specific timetable for these shutdowns has been established.

***** Jeff: please provide update to this section for on-site and off-site gas concentrations.**

Operation of the on-site migration and odor control system is expected to be a long-term operation lasting between 10 and 20 years, or longer. The City will be budgeting operational programs to last at the site for at least 30 years.

On-site and off-site monitoring of gas concentrations and system performance will be undertaken by the City of Seattle in accordance with the plan outlined in Section 4. This program will continue as long as required.

4.0 POST-CLOSURE AND MONITORING PLAN

4.1 OPERATIONS AND MAINTENANCE CONSIDERATIONS

The operations and maintenance of the Midway Landfill during the post-closure period will be an intensive effort for several years due to the sensitivity of the site and diversity of systems required for closure. A post-closure operations and maintenance (O&M) manual has been completed and approved by the affected regulatory agencies and reviewed by the public prior to the completion of construction.

****** please provide citation for the O&M plan and list in reference section. *****

The purpose of the O&M manual is to provide landfill operations personnel the proper understanding, techniques, and references to efficiently operate and maintain the landfill facilities. Additional objectives include aid to managerial personnel in the planning and budgeting for staff and equipment to carry out the program, and the assurance to regulatory agencies that O&M requirements will be met.

The key elements of the O&M manual are listed in Table 4-1.

4.1.1 O&M DURATION

The duration of operations and maintenance activities at the Midway site is unknown and may vary between systems. Operation and maintenance of the storm drainage system, including the pump station and detention basins, will be perpetual. The City is currently planning for maintenance of all other landfill systems for at least 30 years. This is in accordance with Seattle-King County Health Department Rules and Regulations 8.

4.1.2 O&M REQUIREMENTS

Landfill systems requiring operation and maintenance are outlined in Table 4-1.

***** Please update table 4-1 as necessary for actual present day conditions.**

Table 4-1. Operation & Maintenance Manual - Key Elements

Closure Element	Components Requiring Operation & Maintenance
Final Cover System	Access Roads Barrier Layer Vegetative Cover/Landscaping Leachate Collection System
Surface Water Management Facilities	Detention Basins Pump Station/Pressure Line Gravity Storm Drains Manholes & Structures Open Channels/Ditches
Off-site Landfill Gas Control System	Extraction Well Vents Motor Blowers Carbon Filters
On-site Landfill Gas Control System	Extraction Well Monitoring Manifold Pipeline Valves & Connections Condensate Holding/Disposal Motor Blowers Flares Emission Monitoring
Administration/Management	Organization Staff Requirements Record Keeping Emergency Operations Health & Safety
Financial	Annual Labor Costs Annual Equipment Costs Annual Contract Costs

4.2 GROUND-WATER MONITORING

Ground-water monitoring at the Midway Landfill will be performed in accordance with the guidelines set forth in the State of Washington Minimum Functional Standards, Washington Administrative Code (WAC) 173-304. There are two phases to ground-water monitoring; compliance and performance monitoring. Compliance and performance monitoring are described in the following section.

4.2.1 COMPLIANCE MONITORING

Compliance monitoring includes collection and qualitative analysis of groundwater samples collected from monitoring wells located upgradient and downgradient, and within the Midway Landfill. This section describes the purpose of compliance monitoring, describes the monitoring network, and lab analysis program. Recommendations for future compliance monitoring are presented.

4.2.1.1 Purpose

Groundwater compliance monitoring is intended to:

- Evaluate changes in groundwater quality since 1987 and determine whether groundwater quality downgradient from the landfill has remained relatively constant, or decreased.

- Satisfy requirements for collection of Minimum Functional Standard Parameters (MFSPs) specified in Chapter 173-304-490 for post-closure monitoring at landfills.

4.2.1.2 Current Monitoring Network and Analytical Plan

Seventeen wells are sampled quarterly (March, June, September, and December) as part of the groundwater compliance monitoring program.. These wells chosen from 57 available monitoring wells in the Midway Landfill area. These wells monitor groundwater quality in the Upper Gravel Aquifer (UGA), the Sand Aquifer (SA), and the Southern Gravel Aquifer (SGA). The parameters that are included in the analytical plan, the specific wells selected, their locations, and the reasons for their selection, are discussed below.

4.2.1.3 Analytical Plan

Currently, samples collected from 17 wells are analyzed quarterly for the parameters listed below.

Field temperature	Dissolved iron
Field conductivity	Dissolved manganese

Field pH	Dissolved zinc
Nitrite as nitrogen	Chloride
Nitrate as nitrogen	Sulfate
Ammonia as nitrogen	Chemical oxygen demand
Total coliform	Volatile organics

In addition to the state groundwater monitoring requirements, the Seattle-King County Health Department requires annual testing for the following organic chemicals

Trichloroethylene	Carbon Tetrachloride
Vinyl Chloride	1,2 - Dichloroethane
Benzene	1,1 - Dichloroethylene
1,1,1 - Trichloroethane	p - Dichlorobenzene
Endrin	Lindane
Methoxychlor	Toxaphene
2,4 D	2,4,5 - T.P. Silvex

4.2.1.4 Upper Gravel Aquifer Wells

Four wells, (MW-21A, MW-16, MW-19B, and MW-7A) completed in the UGA, were selected to obtain representative samples of groundwater flowing to the landfill and offsite in the UGA. The approximate locations of these wells are shown in Figure 4-1 and summarized below.

- MW-21A: 400 feet north-northwest and upgradient of the landfill.
- MW-16: 850 feet south and upgradient of the landfill.
- MW-19B: In the middle of the landfill where UGA recharges the SA.
- MW-7A: At the southern edge of the landfill where the UGA discharges into the SA.

***** Please provide figure 4-1 ******

These four wells are monitored because groundwater flows in two general directions (north and south) and also appears to move vertically into the underlying SA in the middle and southern portions of the landfill. The two different flow directions require two upgradient monitoring points (MW-16M and W-21A). In addition, these two wells provide information on groundwater quality as it enters the Midway Landfill. Wells MW-7A and MW-19B monitor water quality downgradient of the landfill. Groundwater from both downgradient wells is indicative of the water quality entering the SA from the UGA.

4.2.1.5 Sand Aquifer Wells

Six wells completed in the SA (MW-21B, MW-8B, MW-17B, MW-30B, MW-15A, and MW-23A) are used for quarterly groundwater monitoring. The approximate well locations are shown in Figure 4-2 and noted below.

- MW-21B: 400 feet upgradient to the north-northwest of the landfill.
- MW-8B: 850 feet southwest and upgradient of the landfill.
- MW-17B: 650 feet west and upgradient of the landfill.
- MW-30B: 2,200 feet southeast of the landfill (this well would likely be downgradient of the landfill, except for the existence of the hydraulic sink between MW-30B and MW-23A).
- MW-15A: 550 feet southeast of the landfill within the hydraulic sink.
- MW-23A: 600 feet east of the landfill, also within the hydraulic sink and possibly downgradient of the landfill.

***** Please provide figure 4-2 *****

These seven wells are used to monitor groundwater in the SA because groundwater generally flows radially towards a hydraulic sink beneath the southern part of the landfill.

Wells MW-21B, MW-17B, and MW-8B monitor flow from the north and west and provide information on upgradient water quality in the SA. MW-30B monitors flow from the east, and groundwater quality beyond the hydraulic sink and MW-15A and MW-23A indicate the quality of water in the area of the hydraulic sink.

An additional well (MW-20A), was added to the monitoring network in the SA. NW-20A is just beyond the western edge of the landfill, and lies downgradient from MW-17B, the most contaminated well in the study area. MW-20A may be impacted by landfill leachate because of its depth and location.

4.2.1.6 Southern Gravel Aquifer Wells

Six wells (MW-24B, MW-20B, MW-14B, MW-23B, and MW-30C) were selected to make up the network in the SGA. The approximate well locations are shown in Figure 4-3 and summarized below:

- MW-24B: 1,100 feet south-southeast of the landfill, near the groundwater divide,
- MW-20B: On the western edge of the landfill, downgradient of the divide and, therefore, downgradient of the landfill's influence.
- MW-14B: On the eastern edge of the landfill at the crest of the divide.
- MW-23B: 600 feet east of the landfill and downgradient of the landfill's influence.
- MW-29B: 1,450 east of the landfill and downgradient of the landfill's influence.
- MW-30C: 2,200 feet southeast of the landfill and downgradient of the landfill's influence.

***** Please provide figure 4-3 *****

These six wells are used to monitor groundwater in the SGA because flow here is complex. A groundwater divide occurs southeast of the landfill. Groundwater movement is generally to the north, the west, and the east.

Monitoring wells MW-14B and MW-24B are located at the crest of the divide. Water quality at MW-24B represents upgradient conditions to the south. Water quality and MW-14B is believed to be indicative of the groundwater entering the SGA aquifer form the overlying SA. Contaminants in the groundwater are diluted and attenuated as leachate-derived contaminants move downgradient to the west and southeast past MW-23B, MW-29B, and MW-30C. MW-30C is at the farthest extent of measurable contaminant migration. MW-20B is downgradient and on the west side of the landfill.

4.2.1.7 Recommended Future Compliance Monitoring

The current monitoring network and analytical plan were evaluated in late 1995 to determine if changes to the monitoring program are appropriate. In light of the complex stratigraphy, the hydrostratigraphic relationships between aquifers, and the time of the closure, it is recommended that the groundwater monitoring network continue using the same 17 wells. It is further recommended that the analytical plan remains the same, except for decreasing the monitoring of VOCs from quarterly to semiannually.

A proposed groundwater analytical testing schedule is presented in Table 4-2. This recommendation is made because collecting VOC data semi-annually would still allow adequate evaluation of steady-state conditions and meet all objectives of the program. As more data becomes available, the monitoring network and analytical plan will be re-evaluated periodically and may be changed at any time with written concurrence from Ecology.

Table 4-2 Proposed Groundwater Analytical Testing Schedule

	March	June	September	December
MFS[1]	X	X	X	X
VOCs[2]		X		X

[1]MFS = Minimum Functional Standards for Solid Waste Handling (173-304 WAC) monitoring parameters are: Temperature, Conductivity, pH, Chloride, Nitrite as Nitrogen, Nitrate as Nitrogen, Ammonia as Nitrogen, Sulfate, Dissolved Iron, Dissolved Zinc, Dissolved Manganese, Chemical Oxygen Demand, Total Organic Carbon, and Total Coliform.

[2]VOCs = Volatile Organic Compounds (EPA method 8240)

4.2.2 PERFORMANCE MONITORING

This section describes the purpose of the current performance monitoring network and provides recommendations for future monitoring.

4.2.2.1 Purpose

Groundwater performance monitoring is intended to:

- Measure changes in leachate elevations in the landfill.
- Measure changes in oil thickness in the landfill.
- Measure shallow groundwater in flow to the landfill aquifer.
- Evaluate the effectiveness of closure action, in reducing leachate volume, and oil thicknesses in the landfill.

4.2.2.2 Current Monitoring Network

The current monitoring program consists of 77 wells and probes which are used to collect water levels. Fifteen of the locations are used in evaluating on-site oil thicknesses. Oil has not been detected outside the boundaries of the Midway Landfill. Water level and oil thickness measurements are currently collected quarterly. Most of the 173 monitoring points are screened in the landfill aquifer and the UGA. A few of the monitoring probes are screened in the SA, SGA, and Northern Gravel Aquifer (NGA).

The current Midway Landfill water level and oil thickness monitoring network was evaluated to determine which wells reliably provided the most useful data. The goal of this evaluation was to determine which wells should be retained for future performance monitoring.

Generally, wells were selected to provide good spatial coverage of each of the key zones. In addition, a few wells were recommended because they have historically been used to generate hydrographs and therefore provide data continuity. Wells that historically have been blocked, or have for another reason not provided useful data, were excluded from the network.

To evaluate the wells and probes for inclusion in the performance monitoring network, the wells and probes were divided into 5 groups based on completion, within the landfill aquifer, UGA, SA, SGA, and NGA. After wells were grouped by aquifer, they were evaluated for reliability, previous data application in hydrographs and piezometric maps, and spatial distribution. The wells which consistently provided the most useful data were included in the performance monitoring network. Wells included from each aquifer are discussed below.

4.2.2.3 Landfill Aquifer

Monitoring wells and probes located within the landfill aquifer were further divided into upper and lower zones. The upper zone is comprised of approximately one-half of the refuse ranging between the bottom of the final landfill cover and 325 feet above mean sea level (MSL). The lower zone includes the low one-half of the refuse and ranges between 325 feet in elevation and 270 feet in elevation.

The purpose of dividing the landfill aquifer into upper and lower zones is only to look at conditions in the upper and lower portions of the fill. These zones do not represent hydraulically distinct units and do not differ significantly in physical properties.

4.2.2.4 Landfill Aquifer - Upper Zone

Most wells in the landfill aquifer upper zone are dry; however, four wells (30, 41S, 50S, and 56S) still have water. Five additional wells (24, 35S, 44D, 48S, and 52S) have been dry but are included for confirmation of dry conditions and to provide spatial coverage. Monitoring well locations are shown on Figure 4-4.

***** Provide figure 4-4 *****

4.2.2.5 Landfill Aquifer - Lower Zone

Wells in the lower zone of the landfill aquifer have been used to generate the piezometric head and flow pattern maps. The basic flow pattern has remained relatively consistent and therefore, a reduced number of monitoring points could provide sufficient information to characterize shallow groundwater and landfill aquifer flow. The selected wells from the lower landfill aquifer are shown in Figure 4-5 and listed below:

> 2, 5, 7, 8, 13, 14, 16, 17, 21, 23, 26, 27, 29, 31, 32, 33, 38D, 39D, 40D, 41D, 42D, 43D, 45D, 46D, 47D, 49D, 50D, 53D, 54D, 55, 56D, PC4S, PC6S, PC7S, LW-1, LW-2, MW-19A.

***** Provide figure 4-5 *****

4.2.2.6 Upper Gravel Aquifer

Eighteen probes and wells completed in the UGA and one monitoring location completed in fill provided the most useful data. The wells and probes recommended for the UGA monitoring network are shown in Figure 4-6 and listed below:

> PA15 (fill), PA2S, PA3S, PA5S, PA6S, PD1S, PD3S, PD4S, PD7S, PD10S, PD11S,

TW-1, TW-2, AN-M, AM-M, AO-M, AR-M, AV-S, and AW-S

*** **Provide figure 4-6** ***

4.2.2.7 Sand Aquifer, Southern Gravel Aquifer, and Northern Gravel Aquifer

Wells screened in the deep aquifers do not provide information relevant to the performance monitoring goals and have therefore not been included in our monitoring plan.

4.2.2.8 Summary of Monitoring Wells

Table 4-3 shows the 77 monitoring wells by aquifer units. These monitoring wells are reduced from the 173 wells installed in the landfill (see Table 2-1). The reduced number of wells reflect the stable hydrogeological and hydrochemical conditions, since monitoring began in October 1989.

Table 4-3 Listing of Performance Monitoring Wells by Aquifers

Wells selected from the Landfill aquifer - upper zone:

24	41S	50S
30	44D	52S
35S	48S	56S

Wells selected from the Landfill aquifer - lower zone:

2	26	42D	PC4S
5	27	43D	PC6S
7	29	45D	PC7S
8	31	46D	LW-1
13	32	47D	LW-2
14	33	49D	MW-19A
16	36D	50D	
17	38D	53D	
20	39D	54D	
21	40D	55	
23	41D	56D	

Wells selected from the Upper Gravel Aquifer:

PA2S (fill)	PA6S	PD10S	AO-M
PA2S	PD1S	PD11S	AR-M
PA3S	PD3S	TW-1	AV-S

PA4S	PD4S	AN-M AW-S
PA5S	PD7S	AM-M

4.2.2.9 Monitoring Schedule

The quarterly monitoring schedule was evaluated to determine if any changes were necessary. The current monitoring program began in October of 1989 and data have been collected on a monthly or quarterly basis since. The landfill aquifer potentiometric surface configuration has undergone little change since December 1989. This indicates that there has been little change in the overall leachate flow directions.

Due to the uniformity of the monitoring data, the frequency of sampling will be reduced from quarterly to semi-annually. Semi-annual sampling will occur during high and low groundwater conditions in May and November. This will provide enough data to still meet performance monitoring objectives.

4.2.3 STATISTICAL ANALYSIS

4.2.3.1 Methods

Four parameters, COD, chloride, conductivity, and chlorinated solvents were selected as indicator parameters for the statistical evaluation of groundwater quality in the downgradient wells at Midway Landfill. For the purpose of this analysis, the parameters COD, chloride, and conductivity were considered indicator parameters for leachate in groundwater. Chlorinated solvents were addressed since these parameters do not occur naturally in groundwater.

4.2.3.2 Data Screening

Time-series plots were generated by aquifer for these parameters - as an initial evaluation of the behavior of the parameter levels at the landfill - from 1986 to 1994. Several remedial actions have taken place since 1986, and examination of the time-series plots was used to determine whether any of the parameter levels in the wells appeared to be affected by one or more of the actions.

The time-series plots indicated that some parameters had experienced either a change in variability over time, an abrupt change in general level at some point in time or both. Some parameters also exhibited decreasing or increasing trends in levels. These changes in the pattern of, or trends in, the data were found primarily for the downgradient wells. Most of the background wells exhibited consistent levels over time, although these levels were often different between background wells within the same aquifer.

The patterns exhibited in the time-series plots for many of the downgradient wells were likely the result of the remedial actions taken at the Midway Landfill site. Since the last remedial action was completed and activated in January 1992, and the groundwater chemistry is changing in response to the engineering controls. Such instability in the downgradient well parameter levels makes the statistical evaluation of the existing downgradient data difficult.

4.2.3.3 Background Versus Downgradient Well Comparisons

The presence of both background and downgradient wells in each aquifer facilitated the use of statistical methods to assess the quality of the groundwater in the aquifers relative to nearby background groundwater quality. Using the guidelines given by Ecology (1992, 1993 ****** provide complete citation in reference section)**, 95 percent upper confidence limits (UCLs) were computed for the downgradient wells and compared to area background levels computed from the background wells. These comparisons were performed separately for the wells in each aquifer.

Using the data from the background wells, area background values were computed, and these values were then compared to downgradient well 95 percent UCLs to evaluate the groundwater quality at the downgradient wells. The methods discussed below are explained in detail in Ecology (1992, 1993) with the most recent methodology, including the handling of nondetect (ND) data (Ecology 1993).
***** Provide complete citations in reference section *****

4.2.4 RESULTS OF GROUNDWATER MONITORING

***** Please provide update to this section for 1997 data (or 1998 data if available at this time) *****

This section evaluates trends in groundwater chemistry by comparing 1994 analytical data with previous monitoring rounds. Groundwater samples were collected quarterly in the months of March, June, September, and December 1994. The purpose of the groundwater chemistry monitoring program is to evaluate changes in groundwater chemistry and determine if groundwater conditions downgradient from the landfill has been relatively constant over time. The following parameters were evaluated:

- chloride
- chemical oxygen demand (COD)
- conductivity
- iron, manganese
- sulfate
- total organic carbon (TOC)
- chlorinated solvents

4.2.4.1 Upper Gravel Aquifer

The compounds tested for in MW-16 and in MW-21A (before going dry) have been relatively stable. Chlorinated solvents were not detected in samples from these two wells.

4.2.4.2 Sand Aquifer

The following compounds in the SA have been relatively stable: iron, manganese, and sulfate.

- Chloride - Chloride was relatively stable in the SA except in MW-20A where concentrations appeared to be decreasing before it went dry.
- COD - COD concentrations were varied within a stable range except for MW-20A where the concentration appeared to be decreasing before it went dry.
- Conductivity - Conductivity concentrations were stable in wells MW-8B and MW-30B. In contrast, concentrations in MW-17B, MW-21B, and MW-20A fluctuated and no clear trend was discernible.
- TOC - Concentrations of TOC fluctuated and no clear trend was detectable except MW-20A may have been decreasing slightly prior to going dry.
- Chlorinated solvents - When detected, chlorinated solvent concentrations were relatively stable. One exception was MW-17B where the concentration was variable but within historical values.

4.2.4.3 Southern Gravel Aquifer

The following compounds in the SGA have been relatively stable (or varied within a stable range): COD, conductivity, sulfate, TOC, and chlorinated solvents.

- Chloride - Chloride concentrations were generally stable in the SGA except in MW-20B where concentrations appear to be increasing slightly.
- Iron - For the most part, iron concentrations were either stable or varied within a stable range. Exceptions occurred during QM-18 where historic high concentrations or iron were detected in samples from MW-14B, MW-20B, MW-24B, and MW-29B.
- Manganese - Manganese concentrations were generally stable except for a slight increase in MW-20B.

4.2.5 GROUNDWATER MONITORING AND REMEDIAL ACTIONS

The preferred remedial alternative at the Midway Landfill includes source control and post remediation liquid level and groundwater chemistry monitoring. The purpose of the source control measures is to minimize the amount of water in the landfill. The results of liquid level monitoring indicate that the source controls conducted at the landfill are producing positive results and that the landfill is become dryer.

Based on the analysis completed in the Feasibility Study and the Endangerment Assessment, it was predicted that there would be a delay between effective source control and improvement in downgradient water quality. The water chemistry monitoring confirms that there is a delayed response, although improvements have already been observed in the shallower aquifers. Water chemistry monitoring indicates improvement in the Upper Gravel Aquifer and slight improvement in the Sand Aquifer at this time which is consistent with groundwater remediation by source control.

Based on the data collected to date, the remediation of the Midway Landfill has been effective. Fluid levels within the landfill continue to drop, and groundwater chemistry has improved and is expected to continue to improve. No further remediation is anticipated at this time.

We also recommend assessing the monitoring results every year and reassessing the scope of the monitoring program on a yearly interval.

4.2.5.1 Monitoring Schedule

The quarterly monitoring schedule was evaluated to determine if any changes were necessary. The current monitoring program began in October of 1989 and data have been collected on a monthly or quarterly basis since. The landfill aquifer potentiometric surface configuration has undergone little change since December 1989, suggesting that there has been no change in the overall leachate flow directions.

Due to the uniformity of the monitoring data, the frequency of monitoring may be semi-annual to monitor high and low groundwater conditions in May and November. It is recommended that the scope of landfill groundwater quality and fluid monitoring results be assessed yearly.

4.3 LANDFILL GAS MONITORING PROGRAM

The landfill gas monitoring program for Midway is divided into three components:

- Off-site probes and extraction wells
- Off-site structures
- On-site extraction wells and flares

4.3.1 OFF-SITE PROBES AND EXTRACTION WELLS

Figure 4-7 shows the locations of gas probes and off-site gas extraction wells. All probes and wells were initially monitored bi-weekly for gas pressure, temperature, and combustible gas concentration. Selected probes and extraction wells were also tested periodically for priority pollutants and volatile organic compounds. Barometric pressure was also recorded during every monitoring run. Sampling frequencies of off-site probes and wells were revised as off-site gas concentrations decrease. All scheduled reduction of monitoring frequency will be coordinated with Washington Department of Ecology (Ecology) and the Seattle-King County Health District (SKCHD).

***** Provide figure 4-7. Provide reference to reports that show gas testing results. ****

4.3.2 OFF-SITE STRUCTURES

The City of Seattle is currently monitoring homes and businesses in the vicinity for the presence of landfill gas. ***** (Is monitoring still done now?) ***** The schedule for monitoring these structures varies according to levels of recorded gas concentrations and may include daily, weekly, or monthly testing. This program is dependent upon the effectiveness of the off-site gas extraction effort and will continue as long as is required to demonstrate that gas concentrations in off-site structures are within regulatory limits. Reductions of monitoring frequencies in off-site structures will be coordinated with Ecology and SKCHD.

**** Please update section 4.3.2 for current monitoring schedule for off-site structures. ****

4.3.3 ON-SITE EXTRACTION WELLS AND FLARES

Monitoring of the on-site gas control system is required to maintain system performance, as well as demonstrate air quality compliance. Of particular concern, especially with the peripheral migration control wells, is the intrusion of oxygen into the landfill and associated fire hazards. Accordingly, these wells are monitored for the following parameters:

- combustible gas concentrations (% CH_4)
- oxygen concentration (% O_2)
- temperature (°C)
- carbon dioxide (CO_2)

Prior to entering the flare system, the gases are monitored separately. Daily measurements of combustible gas concentration, temperature, and flow rate are recorded. The chemical constituents of this raw gas stream were test periodically. The gas composition is summarized in Section 2.8.

To ensure that the post-combustion gas stream meets air quality requirements, emissions from the flare assembly will be monitored during start-up and compared with gas combustion temperatures. Based upon the results of this monitoring, a long-term monitoring schedule has been developed. The frequency of monitoring and parameters to be monitored meet the requirements of the Puget Sound Air Pollution Control Agency.

***** Provide section of frequency of gas monitoring and parameters monitored. *****

The entire motor blower and flare assembly is equipped with automatic monitoring equipment for potential operational problems such as power failure and flameout. These functions will be automatic and remotely monitored on a 24-hour basis with immediate notification provided to emergency repair personnel.

5.0 CONTINGENCY PLAN

The leachate management plan may not totally prevent off-site migration of leachate. Should the compliance monitoring program indicate that leachate migration is continuing or re-occurs, or if water quality is not improving, a contingency plan is prepared to implement remedial actions to correct problems.

The Contingency Plan for the Midway site is formulated in conjunction with the RI/FS completed in 198_ **(*** provide date and provide citation for contingency plan ***)**. Implementation of any contingency remedial action element would be determined on the basis of the results of the groundwater/surface water monitoring program.

Appropriate remedial actions beyond the final cover and surface water programs now proposed for implementation require much more detailed investigations of the site prior to developing a specific action. These investigations include such elements as conducting hydrological and hydrogeological studies, preparing design options, feasibility studies and cost estimates, and considering various legal and political limitations. The investigations will also have to include changes in the existing groundwater system caused by the closure plan, prior to instituting any contingency plan involving groundwater pumping or interception.

The current "Remedial Investigation/Feasibility Study" (RI/FS) being conducted at the site under CERCLA should provide the necessary database from which appropriate additional remedial action programs could be selected, if required. A public process for review and comment will be undertaken prior to implementation of contingency plans. Additional documentation for compliance with the State Environmental Policy Act may also be required. Potential remedial action alternatives which would be applicable at Midway are presented below.

5.1 REPAIR OF THE FINAL COVER

Surface water contamination could occur as a result of damage to the final cover. Damage could originate from differential settlement, erosion, or heavy equipment. If such damage occurs, it will be corrected promptly to avoid contamination problems. If the source of the problem is not obvious from observing the surface, then it would indicate a failure of the barrier layer and movement of leachate into the drainage layer with subsequent movement into the storm drain system. The area where the problem is originating could be located by testing the quality of the water at each of the various points along the perimeter drainage ditch. After the area of origin is located, the barrier layer in that portion of the landfill could be exposed and the point of failure corrected.

5.2 GROUNDWATER PUMPING

If monitoring indicates that the leachate is entering the groundwater at unacceptable levels as determined by Ecology and SKCHD, a groundwater pumping program is a possible alternative. The number and spacing of pumping wells would be determined after a detailed hydrogeological study that would evaluate the characteristics of the aquifer in which the leachate is migrating. The disadvantage of this system is that it is expensive to construct and operate. To remain effective, it must operate continuously, and since the water pumped out of the wells must be assumed to be contaminated, it cannot be discharged without treatment. The wells must also be pumped at a fairly high rate, making transport to a treatment facility by tanker truck an unfeasible alternative. Pipeline transport to the local sewer system could be an alternative.

Another treatment method that could be employed is bioreclamation. Using this method, a downgradient well withdraws contaminated water, which is then pumped to an upgradient well. At the upgradient well, the contaminated water is mixed with oxygen, nutrients and bacteria and then injected back into the ground through the upgradient well. The bacteria then metabolize the contaminants in the leachate. Prior to implementing a bioreclamation treatment process, it would be necessary to experiment with a pilot treatment system to determine which bacteria are most effective in degrading the contaminants in the leachate. Additional treatment would probably be required to remove contaminants which are not biodegradable.

5.3 LEACHATE CONTROL

The interception of leachate before it reaches the groundwater is an additional remedial action alternative. A reduction in the quantity of leachate reaching the groundwater could be accomplished by a system designed to collect a portion of the leachate within the landfill.

At Midway, leachate tends to accumulate in two low areas of the landfill: The base of the old gravel pit and Lake Mead, which existed before the filling began. The infiltration of leachate into the groundwater may be inhibited by low permeability peat and clay deposits in these areas. A series of wells placed in the vicinity of these low areas could be pumped to maintain the leachate at the lowest possible levels, thus reducing contact with groundwater. Leachate pumped out could be delivered along with the leachate collected by the toe seep system to the Kent Highlands Landfill for treatment and disposal.

5.4 ALTERNATIVE WATER SUPPLY

The performance of the contingency remedial alternatives may require that substitute water supplies be developed for affected downgradient users. Options include abandonment of existing wells and connection to an uncontaminated public supply; deepening of wells to utilize lower confined aquifers; or the installation of treatment facilities to provide treatment and disinfection prior to domestic use.

6.0 FUTURE LAND USE

Following final closure of the Midway Landfill, land uses and activities in the vicinity of the site will benefit from an improved environment. Closure will reduce odors and other potential nuisances and create a more aesthetically pleasing appearance. However, use of the landfill site itself will be severely restricted. Maintenance of the integrity of the final cover system and continuous operation of the gas control will be very important for the first 2-4 years following closure. Once the landfill area has stabilized and the environmental control systems are operating satisfactorily, other uses of certain portions of the landfill may be possible.

Land uses for closed landfills include open space; active recreational uses such as playfields, golf course; and in some cases light industrial/commercial uses. Some or all of these uses may prove feasible for the Midway site. Uses not recommended for development at Midway include residential or heavy industrial development. The landfill area is currently zoned general commercial.

Regardless of use, certain basic restriction will apply in order to maintain the objectives of the closure program. The objectives are minimizing leachate production and controlling landfill gas. These objectives require that the final cover system be maintained and any penetration, such as buried utility lines or foundation, be satisfactorily sealed to prevent surface water infiltration or gas migration. Any building foundation or surface slabs will require design adaptation to withstand or accommodate settlement. All enclosed structures will require landfill gas monitoring and alarm systems. Landscape beautification other than turf grass will require additional topsoil to ensure adequate depths for deeper rooting plants.

During the initial 2-4 year period following closure, landfill portions of the site will remain as open space while various closure elements are monitored for effectiveness and stability. At the end of the period, site stability will be reviewed with Ecology and SKCHD. When Ecology and SKCHD have determined that the site area has stabilized and environmental control systems are operating satisfactorily, a land use plan will be developed and offered for public review and comment. Any additional documentation necessary to comply with the State Environmental Policy Act will be prepared prior to public review of the land use plan.

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